

PROJECT MANUAL

FOR

CAPE HENLOPEN SCHOOL DISTRICT

CAPE HENLOPEN HIGH SCHOOL ADDITIONS

CAPE HENLOPEN SCHOOL DISTRICT
1270 KINGS HIGHWAY
LEWES, DELAWARE 19958

OWNER

ABHA ARCHITECTS
1621 N. LINCOLN STREET
WILMINGTON, DELAWARE 19806
(302) 658-6426 FAX (302) 658-8431

ARCHITECTS

DAVIS, BOWEN & FRIEDEL, INC.
1 PARK AVENUE
MILFORD, DELAWARE 19963
(302) 424-1441

CIVIL ENGINEERS

MACINTOSH ENGINEERING
2 MILL ROAD #100
WILMINGTON, DE 19806
(302) 252-9200 FAX (302) 252-9201

STRUCTURAL ENGINEERS

GIPE ASSOCIATES
8719 BROOKS DRIVE
EASTON, MARYLAND 21601
(410) 822-8688

**MECHANICAL/ELECTRICAL/PLUMBING
ENGINEERS**

CORSI ASSOCIATES
1489 BALTIMORE PIKE
SPRINGFIELD, PENNSYLVANIA 19064
(610) 541-0822 FAX (610) 541-0824

FOOD SERVICE CONSULTANT

R. ROBINSON LANDSCAPE ARCHITECTS, INC.
30 BANCROFT MILLS ROAD
WILMINGTON, DELAWARE 19806
(302) 888-1544

LANDSCAPE ARCHITECT

ABHA PROJECT NUMBER: 1812

DATE: JULY 31, 2019

CD REVIEW VOLUME 3 OF 4 DIVISION 21 - 23



1621 N. Lincoln St.
Wilmington, DE 19806
(P) 302.658.6426
(F) 302.658.8431
abhagen@ABHA.com
www.ABHA.com

Pages**VOLUME I****DIVISION 00 – CONTRACT REQUIREMENTS****INTRODUCTORY INFORMATION**

00 01 01	TITLE PAGE/CONSULTANT DIRECTORY	1
00 01 10	TABLE OF CONTENTS	6
00 01 15	LIST OF DRAWINGS	3
00 11 16	ADVERTISEMENT FOR BID	1

PROCUREMENT INFORMATION

00 21 13	INSTRUCTIONS TO BIDDERS	12
00 41 26	BID FORMS INCLUDING: BID FORM	9
	SUB LISTING	
	NON-COLLUSION STATEMENT	
004313	STATE OF DELAWARE BID BOND	1

CONTRACTING INFORMATION

00 52 26	AGREEMENT INCLUDING STANDARD FORM OF AGREEMENT BETWEEN OWNER AND CONTRACTOR (AIA A132 – 2009)	11
00 61 13.13	STATE OF DELAWARE PERFORMANCE BOND FORM	2
00 61 13.16	STATE OF DELAWARE PAYMENT BOND FORM	2
00 62 76	MONTHLY REQUISITION & CONTINUATION SHEET (AIA G732-2009 & G703-1992)	1
00 63 00	STANDARD FORMS CERTIFICATES AND MODIFICATION FORMS	1
00 72 26	GENERAL CONDITIONS OF THE CONTRACT FOR CONSTRUCTION (AIA A23 2009)	43
00 73 00	SUPPLEMENTARY GENERAL CONDITIONS A232-2009 INCLUDING ATTACHMENT “A”	9
	CONSTRUCTION MANAGER GENERAL CONDITIONS	5
00 73 16	INSURANCE INCLUDING SAMPLE CERTIFICATE OF INSURANCE	1
00 73 46	DELAWARE PREVAILING WAGE RATES	1
00 80 00	GENERAL REQUIREMENTS	15
00 81 14	DRUG TESTING FORMS	2
00 93 00	REFERENCE MATERIALS	1
	GEOTECHNICAL REPORT (BORING LOGS)	
	PAYROLL REPORT FORM	1

DIVISION 01 - GENERAL REQUIREMENTS

01 11 00	SUMMARY OF WORK	42
01 12 00	MULTIPLE CONTRACT SUMMARY	7
01 12 16	ALTERATION PROJECT PROCEDURES	3
01 14 00	WORK RESTRICTIONS	1
01 20 00	PRICE AND PAYMENT PROCEDURES	3
01 21 00	ALLOWANCES	3
01 22 00	UNIT PRICES	3
01 23 00	ALTERNATES	3
01 25 00	SUBSTITUTION PROCEDURES	3
01 26 00	CONTRACT MODIFICATION PROCEDURES	2
01 29 00	PAYMENT PROCEDURES	4
01 29 73	SCHEDULE OF VALUES	1
01 31 00	PROJECT MANAGEMENT AND COORDINATION	4
01 31 13	PROJECT COORDINATION	4
01 32 16	CONSTRUCTION SCHEDULE	3

01 32 33	CONSTRUCTION PROGRESS DOCUMENTATION	7
01 33 00	SUBMITTAL PROCEDURES	9
01 33 01	CADD RELEASE FORM	1
	REVIT RELEASE FORM	1
01 33 19	FIELD ENGINEERING	3
01 35 00	SAFETY	6
01 40 00	QUALITY CONTROL	3
01 41 00	REGULATORY REQUIREMENTS	7
01 42 00	REFERENCES	16
01 42 19	REFERENCE STANDARDS	1
01 50 00	TEMPORARY CONSTRUCTION UTILITIES, FACILITIES & CONTROLS	18
01 60 00	MATERIALS AND EQUIPMENT PRODUCT REQUIREMENTS	5
01 70 00	CONTRACT CLOSEOUT	4
01 73 29	CUTTING AND PATCHING	4
01 74 19	CONSTRUCTION WASTE MANAGEMENT	6
01 75 00	FACILITY STARTUP/COMMISSIONING	2
01 77 00	CLOSEOUT PROCEDURES	7
01 78 36	WARRANTIES	3
01 80 00	STATEMENT OF SPECIAL INSPECTIONS	9
01 91 13	GENERAL COMMISSIONING REQUIREMENTS	10
01 91 14	PLUMBING COMMISSIONING REQUIREMENTS	9
01 91 15	HVAC COMMISSIONING REQUIREMENTS	12
01 91 16	ELECTRICAL SYSTEMS COMMISSIONING REQUIREMENTS	6

VOLUME 2**DIVISION 03 - CONCRETE**

03 30 00	CAST-IN PLACE CONCRETE	23
03 30 50	INTEGRAL CONCRETE WATERPROOFING	4
03 48 00	PRECAST CONCRETE STAIR TREADS	4
03 49 00	GLASS-FIBER REINFORCED CONCRETE	6

DIVISION 04 - MASONRY

04 20 00	UNIT MASONRY	5
04 22 50	ARCHITECTURAL CONCRETE MASONRY UNITS	5
04 72 00	CAST STONE MASONRY	4

DIVISION 05 - METALS

05 12 00	STRUCTURAL STEEL	9
05 21 00	STEEL JOIST FRAMING	5
05 31 00	STEEL DECKING	6
05 40 00	COLD-FORMED METAL FRAMING	7
05 44 00	COLD-FORMED METAL TRUSSES	5
05 50 00	METAL FABRICATIONS	6
05 51 00	METAL STAIRS	6
05 73 13	ARCHITECTURAL GLASS RAILING	6

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

06 10 00	ROUGH CARPENTRY	5
06 20 00	FINISH CARPENTRY	3

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

07 11 13	BITUMINOUS DAMPPROOFING	2
07 13 00	SHEET WATERPROOFING	5
07 21 00	THERMAL INSULATION	4
07 21 29	SPRAYED ACOUSTICAL INSULATION	3
07 25 00	WEATHER BARRIERS	6
07 26 16	UNDER-SLAB VAPOR BARRIER/RETARDER	2
07 26 40	SPRAY POLYURETHANE FOAM INSULATING AIR BARRIER	7
07 31 13	ASPHALT SHINGLES	5
07 41 13	METAL ROOF PANELS	4
07 42 13	METAL WALL PANELS	6
07 53 00	ELASTOMERIC MEMBRANE ROOFING	7
07 62 00	SHEET METAL FLASHING AND TRIM	4
07 71 23	MANUFACTURED GUTTERS AND DOWNSPOUTS	2
07 72 00	ROOF ACCESSORIES	3
07 81 00	APPLIED FIREPROOFING	4
07 81 23	INTUMESCENT FIREPROOFING	3
07 84 00	FIRESTOPPING	4
07 84 13	FIRE PROTECTION, HVAC & PLUMBING PENETRATION FIRESTOPPING	8
07 92 00	JOINT SEALANTS	7
07 95 13	EXPANSION JOINT COVER ASSEMBLIES	4

DIVISION 08 - OPENINGS

08 11 13	HOLLOW METAL DOORS AND FRAMES	9
08 11 16	ALUMINUM DOORS AND FRAMES	5
08 14 16	FLUSH WOOD DOORS	4
08 31 00	ACCESS DOORS AND PANELS	3
08 32 23	SLIDING AND FOLDING GLAZED WALLS AND DOORS	4
08 33 13	COILING COUNTER DOORS	3
08 33 23	OVERHEAD COILING DOORS	5
08 35 13.23	ACCORDIAN FOLDING FIRE DOORS	3
08 43 13	ALUMINUM-FRAMED STOREFRONTS	6
08 44 13	GLAZED ALUMINUM CURTAIN WALLS	6
08 51 13	ALUMINUM WINDOWS	8
08 71 00	DOOR HARDWARE	22
08 80 00	GLAZING	8
08 83 00	MIRRORS	2
08 91 00	LOUVERS	3

DIVISION 09 - FINISHES

09 05 61	COMMON WORK RESULTS FOR FLOORING PREPARATION	5
09 21 16	GYPSUM BOARD ASSEMBLIES	8
09 30 00	TILING	6
09 51 00	ACOUSTICAL CEILINGS	5
09 54 20	SPECIALTY CEILING SYSTEMS	9
09 65 00	RESILIENT FLOORING	6
09 66 23	EPOXY-RESIN TERRAZZO FLOORING	15
09 67 00	TROVELED SEAMLESS FLOORING	4

09 68 13	TILE CARPETING	3
09 68 16	SHEET CARPETING	1
09 77 20	GRAPH MODULAR WALL SYSTEM	3
09 81 00	ACOUSTICAL INSULATION	4
09 91 13	EXTERIOR PAINTING	7
09 91 23	INTERIOR PAINTING	6

DIVISION 10 - SPECIALTIES

10 11 01	VISUAL DISPLAY BOARDS AND DISPLAY CASES	3
10 21 13.19	PLASTIC TOILET COMPARTMENTS	3
10 21 23	CUBICLE CURTAINS	2
10 22 39	FOLDING PANEL PARTITIONS	3
10 23 10	GLAZED INTERIOR WALL AND DOOR ASSEMBLIES	3
10 26 00	WALL AND DOOR PROTECTION	2
10 28 00	TOILET ACCESSORIES	3
10 44 00	FIRE PROTECTION SPECIALTIES	3
10 73 16.13	ALUMINUM CANOPY SYSTEM	4

DIVISION 11 - EQUIPMENT

11 31 13	RESIDENTIAL APPLIANCES	6
11 40 00	FOODSERVICE EQUIPMENT	24
11 52 13	PROJECTION SCREENS	4

DIVISION 12 - FURNISHINGS

1224 13	WINDOW TREATMENT – ROLLER SHADES	4
12 34 00	LAMINATE CLAD CASEWORK	7
12 35 53.19	WOOD LABORATORY CASEWORK	7
12 36 00	COUNTERTOPS, BACKSPLASHES AND WINDOW STOOLS	4

DIVISION 14 - CONVEYING EQUIPMENT

14 21 00	MACHINE ROOM-LESS (MRL) TRACTION ELEVATORS	9
----------	--	---

VOLUME 3**DIVISION 21 – FIRE PROTECTION**

21 05 00	COMMON WORK RESULTS FOR FIRE PROTECTION	19
21 05 05	FIRE PROTECTION PIPING, FITTING AND VALVES	13
21 10 03	WATER BASED FIRE SUPPRESSION SYSTEM – SPRINKLER & STANDPIPES	14

DIVISION 22 – PLUMBING

22 05 00	COMMON WORK RESULTS FOR FIRE PLUMBING	28
22 05 05	PLUMBING PIPING, FITTING AND VALVES	25
22 07 01	PLUMBING INSULATION	12
22 40 00	PLUMBING FIXTURES	19
22 40 05	PLUMBING EQUIPMENT	17

DIVISION 23 – HVAC

23 05 00	COMMON WORK RESULTS FOR HVAC	33
23 05 05	HVAC PIPING, FITTING AND VALVES	33
23 05 48	VIBRATION CONTROLS FOR HVAC, PLUMBING & FIRE PROTECTION EQUIPMENT	12
23 05 93	TESTING, ADJUSTING & BALANCING FOR HVAC & PLUMBING	25
23 06 00	HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT	49
23 07 01	HVAC INSULATION	16
23 09 00	INSTRUMENTATION & CONTROLS OF HVAC & PLUMBING SYS.	63
23 30 00	HVAC AIR DISTRIBUTION	23
23 81 25	VRF SPLIT SYSTEM WITH HEAT RECOVERY (AIR COOLED)	17

VOLUME 4**DIVISION 26 – ELECTRICAL**

26 05 00	COMMON WORK RESULTS FOR ELECTRICAL	36
26 05 10	ELEVATOR EQUIPMENT WIRING & PROVISIONS	5
26 05 12	KITCHEN EQUIPMENT WIRING	5
26 05 19	CONDUCTORS AND CABLES	16
26 05 26	GROUNDING AND BONDING	9
26 05 28	ELECTRICAL FIRESTOPPING	8
26 05 29	HANGERS AND SUPPORTS	10
26 05 33	RACEWAY AND BOXES	20
26 05 34	SURFACE METAL RACEWAY	6
26 05 35	MISCELLANEOUS RACEWAY SYSTEM	4
26 05 43	UNDERGROUND DUCTBANKS	14
26 05 45	UTILITY HOLES	6
26 05 53	ELECTRICAL IDENTIFICATION	9
26 09 43	NETWORK LIGHTING CONTROLS	19
26 22 00	TRANSFORMERS	10
26 24 13	SWITCHBOARDS, CIRCUIT BREAKER TYPE, MODIFICATIONS	8
26 24 16	PANELBOARDS	19
26 27 26	WIRING DEVICES	15
26 28 13	FUSES	6
26 28 16	DISCONNECT SWITCHES AND CIRCUIT BREAKERS	6
26 29 13	MOTOR CONTROLLERS	8
26 41 13	LIGHTING PROTECTION SYSTEM	11
26 51 00	INTERIOR LIGHTING	17
26 5 600	EXTERIOR LIGHTING	13

DIVISION 27 – COMMUNICATION SYSTEMS

27 05 00	TELECOMMUNICATIONS PATHWAYS AND SPACES	7
27 10 00	STRUCTURED CABLING	14
27 40 00	AV SYSTEMS	7
27 50 00	INTERCOM AND CLOCKS	8

DIVISION 31 – EARTHWORK

31 00 00	EARTHWORK	6
31 10 00	SITE CLEARING	2

31 11 00	CLARING AND GRUBBING	2
31 23 00	EXCAVATION AND BACKFILL FOR PIPELINES AND STRUCTURES	7
31 25 00	EROSION & SEDIMENT CONTROL	2
31 31 16	TERMITE CONTROL	1
31 32 00	SOIL STABILIZATION	3
31 50 00	EXCAVATION SUPPORT AND PROTECTION	2

DIVISION 32 – EXTERIOR IMPROVEMENTS

32 11 26	BITUMINOUS STABILIZED BASE COURSES	2
32 11 36	CONCRETE BASE COURSES	2
32 12 16	ASPHALT PAVING	4
32 13 12	SITE CONCRETE	12
32 13 13	CONCRETE PAVING (SIDEWALKS)	2
32 13 73	CONCRETE PAVING JOINT SEALANTS	4
32 14 16	UNIT PAVING	9
32 16 00	CURBS AND GUTTERS	1
32 30 00	SITE IMPROVEMENTS AND AMENITIES	1
32 31 00	FENCES AND GATES	2
32 31 19	DECORATIVE METAL FENCES AND GATES	4
32 18 13	SYNTHETIC TURF	3
32 91 13	TOPSOILING	7
32 91 15	AMENDED PLANTING SOIL	5
32 92 00	TURF AND GRASSES	6
32 93 00	PLANTING	11

DIVISION 33 – UTILITIES

33 10 00	WATER UTILITIES	3
33 30 00	SANITARY SEWERAGE SYSTEM	3
33 40 00	STORM DRAINAGE UTILITIES	3

END OF TABLE OF CONTENTS

DIVISION 21 SECTION 210500
COMMON WORK RESULTS FOR FIRE PROTECTION
TABLE OF CONTENTS

PART 1. GENERAL	1
1.1. SUMMARY	1
1.2. PERMITS AND FEES	1
1.3. EXAMINATION OF SITE	1
1.4. CONTRACTOR QUALIFICATION	2
1.5. MATERIALS AND EQUIPMENT	2
1.6. FIRE SAFE MATERIALS	3
1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS	3
1.8. SUBMITTALS, REVIEW AND ACCEPTANCE	3
1.9. SHOP DRAWINGS	4
1.10. SUPERVISION AND COORDINATION	5
1.11. CUTTING AND PATCHING	6
1.12. PENETRATION OF WATERPROOF CONSTRUCTION	6
1.13. CONNECTIONS AND ALTERATIONS TO EXISTING WORK	7
1.14. DEMOLITION	7
1.15. VIBRATION ISOLATION	9
1.16. ALTERNATES	9
1.17. DEFINITIONS	9
PART 2. ELECTRICAL REQUIREMENTS	9
2.1. GENERAL ELECTRICAL REQUIREMENTS	9
2.2. WIRING DIAGRAMS	10
PART 3. EXECUTION	10
3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS	10
3.2. SUPPORTS, HANGERS AND FOUNDATIONS	10
3.3. DEMONSTRATION AND TRAINING VIDEO RECORDINGS	11
3.4. PROVISIONS FOR ACCESS	11
3.5. PAINTING AND FINISHES	12
3.6. CLEANING OF SYSTEMS	12
3.7. COLOR SELECTION	13
3.8. PROTECTION OF WORK	13
3.9. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS	13
3.10. WALL AND FLOOR PENETRATION	14
3.11. RECORD DRAWINGS	14
3.12. WARRANTY	14
3.13. OPERATION AND MAINTENANCE MANUALS	15
3.14. INSTALLATION AND COORDINATION DRAWINGS	16
3.15. PIPING SYSTEMS TESTING	16
3.16. PHASING	16
3.17. OUTAGES	17
END OF SECTION	17

SECTION 21 05 00

COMMON WORK RESULTS FOR FIRE PROTECTION

PART 1. GENERAL

1.1. SUMMARY

- A. All work under Division 21 is subject to the Division 01, General Conditions and Special Requirements for the entire contract.
- B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.
- C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.
- D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, and piping up to the time of rough-in or fabrication.
- E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.
- F. Coordinate the work under Division 21 with the work of all other construction trades.
- G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.
- H. Extend fire protection piping from existing fire pump as necessary and connect to new wet pipe sprinklers and hose valves/standpipes.

1.2. PERMITS AND FEES

- A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.
- B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

- A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner

will be permitted for Contractors failure to do so.

- B. Examine and verify specific conditions described in individual specifications sections.
- C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

- A. Any Contractor or Subcontractor performing work under Division 21 shall be fully qualified and acceptable to the Architect and Owner. Submit the following evidence when requested:
 - 1. A list of not less than five comparable projects which the Contractor completed.
 - 2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.
 - 3. Local and/or State License, where required.
 - 4. Membership in trade or professional organizations where required.
- B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.
- C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

- A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality.
- B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.
- C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.
- D. Substitution will not be permitted for specified items of material or equipment where noted.
- E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

- A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

- A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.
- B. ASTM - American Society for Testing and Materials
- C. FM - Factory Mutual
- D. IBC - International Building Code
- E. IEEE - Institute of Electrical and Electronics Engineers
- F. MSSP - Manufacturers Standards Society of the Valve and Fittings Industry
- G. NEC - National Electrical Code
- H. NEMA - National Electrical Manufacturers Association
- I. NFPA - National Fire Protection Association
- J. UL - Underwriters' Laboratories
- K. State of Delaware Fire Protection Requirements.
- L. All equipment materials, piping and installation shall comply with the codes and standards listed in the enforceable edition of the Applicable National Fire Protection Association Pamphlets.
- M. Fire Protection Systems design, equipment and installation shall comply with the Delaware State Fire Prevention Regulations, latest edition including all Annexes and Addendums.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

- A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.
- B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

- C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.
- D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.
- E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.
- F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.
- G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.
- H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.
- I. For resubmissions, the Contractor must address in writing all of the Engineer's comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

- A. Prepare and submit shop drawings for all mechanical equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.
- B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.
- C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.
- D. Items and Systems
 - 1. Access Doors/Panels including layout and location

2. Alarm Check Valves
 3. Coordinated Drawings
 4. Drip Pans
 5. Exterior Equipment/Piping Supports
 6. Fire Protection System including Hydraulic Calculations, Equipment and Devices
 7. Fire Stopping - Methods and Materials
 8. Hose Valve Cabinets and Hose Valves
 9. Identification System
 10. Material and Equipment List
 11. Operations and Maintenance Manuals
 12. Pipe Materials Including Itemized Schedule
 13. Preliminary Pipe Pressure Tests
 14. Pressure Gauges
 15. Strainers
 16. Test Certificates
 17. Valves
 18. Wiring Diagrams, Flow Diagrams and Operating Instructions
 19. Zone Valve Assemblies
- E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.
- F. For any shop drawing requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.
- 1.10. SUPERVISION AND COORDINATION**
- A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

- B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, equipment, and other work performed under Division 21.
- C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for fire protection installations.
- D. Coordinate electrical work required under Division 21 with that under Division 26. Coordinate all work under Division 21 with work under all other Divisions.
- E. Supply services of an experienced (10 years minimum) and competent Project Manager to be in constant charge of work at site.
- F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.
- G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.
- H. Coordinate installation of large equipment requiring positioning before closing in building.

1.11. CUTTING AND PATCHING

- A. Accomplish all cutting and patching necessary for the installation of work under Division 21. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and workmanlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.
- B. Do not cut structural members without approval from the Architect or Structural Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

- A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.
- B. Where pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.
- C. Furnish and install pitch pockets or weather tight curb assemblies where required.
- D. Furnish and install curbs, specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer's instructions, the National Roofing

Contractors Association, SMACNA, and as required by other divisions of these specifications.

1.13. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

- A. Unless otherwise noted on the drawings, where existing fire protection work is removed, pipes, valves, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.
- B. Where work specified in Division 21 connects to existing equipment and piping, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.
- C. Where the work specified under Division 21, or under other Divisions, requires relocation of existing equipment, piping, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition.
- D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.14. DEMOLITION

- A. Unless otherwise noted all existing equipment, piping, etc., shall remain.
- B. Where existing equipment is indicated to be removed, all associated piping, conduit, power, controls, insulation, hangers, supports and housekeeping pads, etc. Patch, paint and repair walls/roof/floor to match existing and/or new finishes.
- C. Provide necessary piping, valves, temporary feeds, etc., as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time lengths of outages.
- D. The Contractor shall be responsible for visiting the site and determining the existing conditions in which the work is to be performed.
- E. Where any abandoned pipes in existing floors, walls, pipe tunnels, ceilings, etc., conflict with new work, remove abandoned pipes as necessary to accommodate new work.
- F. The location of all existing equipment, piping, etc., indicated is approximate only and shall be checked and verified. Install all new fire protection work to connect to or clear existing work as applicable.
- G. Maintain egress at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and the authorities having jurisdiction.
- H. Make provisions and include in bid all costs associated with confined entry/space requirements and all other applicable OSHA regulations.

- I. Where required to maintain the existing systems in operation, temporarily backfeed existing systems from new equipment. Contractor shall temporarily extend existing piping systems to new piping systems with the appropriate shut-off valves and tamper switches.
- J. At completion of project all temporary piping, valves, controls, etc., shall be removed in their entirety.
- K. Existing piping, equipment, materials, etc., not required for re-use or re-installation in this project, shall be removed from the project site.
- L. Deliver to the Owner, on the premises where directed, existing equipment and materials which are removed and which are desired by the Owner or are indicated to remain the property of the Owner.
- M. All other materials and equipment which are removed shall become property of the Contractor and shall be promptly removed, from the premises, and disposed of by the Contractor, in an approved manner.
- N. Where piping is removed, remove all pipe hangers which were supporting the removed piping. Patch the remaining penetration voids with like materials and paint to match existing construction.
- O. Where required, provide and coordinate removal and re-installation of existing equipment. Take care to protect materials and equipment indicated for reuse. Contractor shall repair or replace items which are damaged. Contractor shall have Owner's representative present to confirm condition of equipment prior to demolition.
- P. Before demolition begins, and in the presence of the Owners representative, test and note all deficiencies in all existing systems affected by demolition but not completely removed by demolition. Provide a copy of the list of system deficiencies to the Owner and the Engineer. Videotape existing conditions in each space prior to beginning demolition work.
- Q. The Owner shall have the first right of refusal for all devices and equipment removed by the Contractor.
- R. All devices and equipment designated by the Owner to remain the property of the Owner shall be moved and stored by the Contractor at a location on site as designated by the Owner. It shall be the Contractor's responsibility to store all devices and equipment in a safe manner to prevent damage while stored.
- S. All existing equipment refused by the Owner shall become the property of the Contractor and shall be removed from the site by the Contractor in a timely manner and disposed of in a legal manner.
- T. Work Abandoned in Place: cut and remove underground pipe a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.
- U. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.
- V. Terminate services and utilities in accordance with local laws, ordinances, rules and

regulations.

1.15. VIBRATION ISOLATION

- A. Furnish and install vibration isolators, flexible connections, supports, anchors and/or foundations required to prevent transmission of vibration from equipment, or piping to building structure. See Division 23 Section, "Vibration Control for HVAC Plumbing and Fire Protection Equipment".

1.16. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

1.17. DEFINITIONS

- A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.
- B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.
- C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.
- D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.
- E. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, embedded in construction or in crawl space.
- F. Exposed means not installed underground or concealed as defined above.
- G. Invert Elevation means the elevation of the inside bottom of pipe.
- H. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceiling, and unexcavated spaces.
- I. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.
- J. Building Line: Exterior wall of building.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL ELECTRICAL REQUIREMENTS

- A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 21 with the

work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 21. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 21.

- B. All electrical work performed under Division 21 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA and the IBC.
- C. Provide wiring diagrams with electrical characteristics and connection requirements.

2.2. WIRING DIAGRAMS

- A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.
- B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.
- B. Install equipment according to approved submittal data. Portions of the work are shown only in diagrammatic form. Refer conflicts to Architect.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install fire protection equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- E. Install equipment giving right of way to piping installed at required slope.
- F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.
- G. Do not install equipment or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

- A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

- B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of galvanized steel utilizing galvanized rods, nuts, washers, bolts, etc. At contractor's option stainless steel may be utilized for exterior hangers, rods, nuts, washers, bolts, etc.

3.3. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

- A. General: Record demonstration and training video recordings. Record each training module separately.
 - 1. At beginning of each training module, record each chart containing learning objective and lesson outline.
- B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer
- C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.
- D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.
- E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.4. PROVISIONS FOR ACCESS

- A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, controls, control devices, and other devices requiring maintenance, service, adjustment, balancing or manual operation.
- B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 24 inches x 24 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.
 - 1. Acoustical or Cement Plaster: Style B
 - 2. Hard Finish Plaster: Style K or L
 - 3. Masonry or Dry Wall: Style M
- C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

- D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish.
- E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.
- F. Where access doors are installed in wet locations (i.e. toilet rooms and similar spaces, etc.) provide aluminum access doors/frames.

3.5. PAINTING AND FINISHES

- A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.
- B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.
- C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.
- D. Protect all finishes and restore any finishes damaged as a result of work under Division 21 to their original condition.
- E. The preceding requirements apply to all work, whether exposed or concealed.
- F. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.
- G. All exposed piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.
- H. All exposed piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

3.6. CLEANING OF SYSTEMS

- A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting equipment, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.
- B. Flush piping to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating the name of Service Company used.

- C. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

- D. Leave systems clean, and in complete running order.

3.7. COLOR SELECTION

- A. Color of finishes shall be as selected by the Architect.
- B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.8. PROTECTION OF WORK

- A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.
- B. Cover temporary openings in piping and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.
- C. Cover or otherwise protect all finishes.
- D. Replace damaged materials, devices, finishes and equipment.
- E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

3.9. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

- A. Contractor shall submit for approval working fire protection drawings of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.
- B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as "Normally Open" or "Normally Closed" as required.
- C. Provide three (3) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Operation and Maintenance Booklet as hereinafter specified.
- D. All piping installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and service. Refer to Division 21 Section, "Fire Protection Piping, Fittings, Valves, Etc". Color code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.
- E. Submit list of wording, symbols, letter size, and color coding for fire protection identification. Submit samples of equipment identification cards, piping labels, and valve

tags to Engineer for review prior to installation.

- F. Provide at least six (6) hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner.
- G. Contractor shall demonstrate Sequences of Operation of all fire protection equipment in presence of Owner's representative, and Fire Marshal.

3.10. WALL AND FLOOR PENETRATION

- A. All penetrations of partitions, ceilings, roofs and floors by piping or conduit under Division 21 shall be sleeved, sealed, and caulked airtight for sound and air transfer control.
- B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC and Plumbing Protection Firestopping".
- C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.
- D. Provide pipe escutcheons for sleeved pipes in finished areas.
- E. Piping sleeves:
 - 1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.
 - 2. Twenty-two (22) gauge galvanized steel elsewhere.
- F. Extend all floor sleeves through floor at least 2-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.

3.11. RECORD DRAWINGS

- A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the fire protection drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.
- B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.12. WARRANTY

- A. Contractor's attention is directed to warranty obligations contained in the GENERAL CONDITIONS.
- B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer's warranties shall be included in the operations and maintenance manuals.

- C. The contractor guarantees for a two year period from the time of final acceptance by the Owner.
 - 1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.
 - 2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.
 - 3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section.
 - 4. That the entire work shall be water-tight and leak-proof.

3.13. OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operation and Maintenance Manuals and deliver these copies of the manuals to the Owner. The manuals shall be as specified herein. The manuals must be approved and will not be accepted as final until so stamped.
- B. The manuals shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manuals –Cape Henlopen High School Expansion – Fire Protection. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.
- C. Provide the following data in the booklet:
 - 1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.
 - 2. Manufacturer's extended limited warranties on equipment.
 - 3. Chart form indicating frequency and type of routine maintenance for all fire protection equipment. The chart shall also indicate model number of equipment, location and service.
 - 4. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.
 - 5. Provide supplier and subcontractor's names, address, and phone number.
 - 6. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.
 - 7. Provide and install in locations as directed by the Owner, valve charts including

valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass.

8. Access panel charts with index illustrating the location and purpose of access panels.
 9. Approved Fire Protection Certificates.
 10. Start-up reports for equipment.
- D. Submit Operations and Maintenance Manuals prior to anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Operations and Maintenance Manuals be reviewed and approved.

3.14. INSTALLATION AND COORDINATION DRAWINGS

- A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following:
1. Complete Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.
- B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment, and piping in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.
- C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.

3.15. PIPING SYSTEMS TESTING

- A. The entire new fire protection piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of four (4) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	TEST PRESSURE
Fire Protection (Refer to NFPA)	200 psi

- B. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

3.16. PHASING

- A. Refer to Architectural Specifications and contract drawings for any required phasing.
- B. Maintain building egress and traffic ways at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and Authorities having jurisdiction.
- C. Provide dust barriers/partitions, penetration closures, etc., to ensure safety of building occupants and protection of existing surroundings.
- D. The Building shall remain watertight at all times.
- E. Refer to phasing plans for additional requirements.
- F. Provide necessary piping, valves, etc. as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time length of outages. Temporarily feed new systems with existing system where required.
- G. Within thirty days of Award of Contract, the Contractor shall submit a minimum of six (6) copies of the proposed Phasing Plan (Drawings and detailed written description) to the Architect for review and approval based on the general and specific requirements indicated on the Drawings and Specifications. The phasing plan shall reflect the work of all trades. The phasing plan shall be updated as often as needed (i.e. major deviations and/or modified sequence of events) and reviewed during each progress meeting so the facility and Architect can be aware of the areas of construction and progress as it relates to the approved schedule.
- H. Due to phased construction, some systems must be operated until later phases are completed.
- I. While work is in progress, except for designated short intervals during which connections are made, continuity of service shall be maintained to all existing systems. Interruptions shall be coordinated with the Owner as to time and duration. The contractor shall be responsible for any interruptions to service and shall repair any damages to existing systems caused by his operations.
- J. After demolition of ceilings install aluminum inverted pie plates above each sprinkler head (as heat trap). Maintain throughout construction phase. Remove with the installation of new ceilings. Submit to Fire Marshall for review and approval.

3.17. OUTAGES

- A. Provide a minimum of fourteen (14) days notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.
- B. Submit Outage Request form, attached at end of this Section, to Owner for approval.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: _____ BY: _____

DATE FOR OUTAGE: _____ FIRM: _____

START OUTAGE-TIME: _____ DATE: _____

END OUTAGE -- TIME: _____ DATE: _____

AREAS AND ROOMS: _____

FLOOR(S): _____

AREA(S): _____

ROOM(S): _____

WORK TO BE PERFORMED: _____

SYSTEM(S): _____

REQUEST APPROVED BY: _____

(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: _____

YES ____ NO ____ BY: _____ DATE: _____

DATE/TIME-AS REQUESTED: _____ OTHER: _____

OWNER'S PRESENCE REQUIRED: _____

YES: ____ NO: ____ NAME: _____

POINT OF CONTACT: _____ PHONE: _____

DIVISION 21 SECTION 21 05 05
FIRE PROTECTION PIPING, FITTINGS & VALVES
TABLE OF CONTENTS

PART 1. GENERAL.....	1
1.1. SUMMARY.....	1
1.2. SYSTEM DESCRIPTION CONDITIONS.....	1
1.3. QUALITY ASSURANCE	1
1.4. DELIVERY, STORAGE AND HANDLING	1
1.5. ENVIRONMENTAL REQUIREMENTS	2
1.6. EXTRA MATERIALS.....	2
1.7. ALTERNATES.....	2
PART 2. PRODUCTS.....	2
2.1. PIPE MATERIALS.....	2
2.2. PIPE HANGERS.....	4
2.3. VALVES.....	6
2.4. PRESSURE GAUGES.....	6
2.5. ESCUTCHEONS.....	6
2.6. DIELECTRIC CONNECTIONS:	6
2.7. SLEEVES	7
2.8. WATER PROOF PIPE PENETRATION SEALS	7
PART 3. EXECUTION.....	7
3.1. GENERAL PIPING INSTALLATION REQUIREMENTS.....	7
3.2. PRESSURE GAGE INSTALLATION REQUIREMENTS.....	8
3.3. VALVE INSTALLATION REQUIREMENTS.....	8
3.4. PIPE JOINTS INSTALLATION REQUIREMENTS.....	9
3.5. HANGERS AND SUPPORTS INSTALLATION REQUIREMENTS	10
3.6. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS.....	11
3.7. VALVE IDENTIFICATION REQUIREMENTS.....	12
END OF SECTION	12

SECTION 21 05 05

FIRE PROTECTION PIPING, FITTINGS AND VALVES

PART 1. GENERAL

1.1. SUMMARY

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SYSTEM DESCRIPTION CONDITIONS

- A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings.
- B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and the authority having jurisdiction.
- C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.
- F. Provide pipe hangers and supports in accordance with ASTM B31.9, MSS SP69 and NFPA-13 unless indicated otherwise.
- G. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

1.3. QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
- C. If the product is available domestically it shall be supplied as such.

1.4. DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to site under as hereinbefore specified.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

- A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

- A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

- A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.
 - 1. Fire Protection Piping (NFPA-13):
 - a. Piping Above Grade (Inside): Steel, schedule 40, ASTM A53, black pipe. Piping 4 inches and smaller shall be ASTM A120, black steel pipe. Sizes 4-inches and above shall be standard weight, black, cast iron with screwed fittings, schedule 10 steel piping shall be acceptable when approved by the authority having jurisdiction.
 - b. Piping Above Grade (Outside): Galvanized Steel
 - c. Wet Pipe Fittings: Steel fittings shall be ASME B16.9, wrought steel, butt welded. Cast iron fittings shall be ASME 16.1, flanges and flanged fittings. Malleable iron fittings shall be ASME B16.3, threaded fittings. Mechanical grooved couplings shall be malleable iron housing clamps to engage and lock C shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe. Mechanical formed fittings shall be carbon steel housing with integral pipe stop and O-ring and O-ring uniformity compressed into permanent mechanical engagement onto pipe.
 - d. Victaulic, Grinnell, or approved equal, grooved end fittings and mechanical couplings shall be used for wet pipe and dry pipe systems 2" and larger. Couplings and fitting shall be UL listed and FM approved. Fittings shall be ASTM A536 ductile iron, ASTM A234 forged steel or ASTM A53 fabricated steel with factory grooved ends designed to accept Victaulic couplings.

- e. Victaulic, Grinnell, or approved equal, mechanical couplings shall consist of two ASTM A536 ductile iron housings, pressure-responsive, synthetic rubber gasket and plated steel bolts and nuts.
 - i. Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with NFPA-13. Tongue and recess rigid type couplings shall only be used if the contractor uses a torque wrench for installation. Required torque shall be in accordance with the manufacturer's latest recommendation.
 - 1) 1-1/4" through 8": "Installation Ready" stab-on rigid coupling, designed for direct 'stab' installation onto grooved end pipe without prior field disassembly and no loose part. Victaulic FireLock EZ Style 009H (1-1/4" – 4") and Victaulic QuickVic Style 107H (2"-8").
 - 1) 2" and Larger: Standard rigid coupling design. Victaulic Style 07 Zero-Flex.
 - ii. Flexible Type: use in seismic areas and where required by NFPA-13.

Fire Protection Service	Temperature Range	Gasket Recommendation
Water/Wet Systems	Ambient	Grade EPDM, Type A-C Shaped, FireLock EZ, or QuickVic Design

- f. Gate Valves: 2-1/2 inches & larger - listed 175 lb. OS&Y, flanged. 2 inches & smaller - UL/FM listed 175 lb., bronze, screwed. Furnish all sprinkler control valves with slow close manual operator and position indicator. Tamper switches furnish under Division 21.
- g. Grooved End Gate Valves: 2-1/2inches and Larger – UL listed/FM approved, 250 psi maximum pressure rating, OS&Y, ductile iron body, bronze mounted, grooved ends. Victaulic FireLock Series 771.
- h. Grooved End Butterfly Valves: 2 inches & Larger: UL listed/FM approved, up to 365 psi maximum pressure rating, ductile iron body, nickel-plated ductile iron disc, Nitrile seat, weather-proof actuator with two pre-wired supervisory switches. Victaulic FireLock Series 765 or Series 705.
- i. Globe Valves: 2 inches & smaller - 175 lb., bronze, screwed, UL/FM listed.
- j. Check Valves: 2-1/2 inches & smaller - UL/FM listed 175 lb., flanged swing check. 2 inches & smaller - listed 175 lb., bronze swing check, screwed.
- k. Grooved End Check Valves: 2 inches and Larger: UL listed/FM approved, up to 365 psi maximum pressure rating, ductile iron body, spring-loaded stainless steel or EPDM coated ductile iron disc, nickel-plated or welded-in nickel seat. Victaulic FireLock Series 717H or Series 717.
- l. Finish: All exposed fire protection piping shall be primed and painted with epoxy red paint. White letters shall indicate pipe and indicate direction of flow. Painting shall be provided under Division 09.
- m. Special Requirements: All fire protection piping, valves, fittings and joints shall comply with applicable National Fire Protection Pamphlets (NFPA) local codes, building codes, Fire Marshal, Owner's Insurance

Underwriter, and the authority having jurisdiction.

- B. Steel pipe shall be similar and equal to National Allied Tube or Wheatland black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.
- C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.
- D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS

- A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260 for pipe $\frac{3}{4}$ -inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
$\frac{3}{4}$ & 1	6	5	$\frac{3}{8}$
1 - $\frac{1}{2}$	6	8	$\frac{3}{8}$
2	8	8	$\frac{3}{8}$
2 - $\frac{1}{2}$	10	9	$\frac{1}{2}$
3	12	10	$\frac{1}{2}$
4	14	12	$\frac{5}{8}$
5	14	12	$\frac{5}{8}$
6	16	14	$\frac{3}{4}$
8	18	16	$\frac{7}{8}$

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
10	20	18	7/8
12	20	18	7/8

- B. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.
- C. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring, comply with NFPA-13.
- D. Hangers for pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis. Comply with NFPA-13.
- E. Hangers for cold pipe sizes 6 inches (150 mm) and over: adjustable steel yoke, cast iron roll, double hanger, comply with NFPA-13.
- F. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.
- G. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook, comply with NFPA-13.
- H. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp, comply with NFPA-13.
- I. Wall support for pipe sizes 6 inches (150 mm) and over: welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll, comply with NFPA-13.
- J. Vertical Support: Steel riser clamp, comply with NFPA-13.
- K. Floor support for pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support, comply with NFPA-13.
- L. Copper pipe support: Carbon steel ring, adjustable, copper plated, comply with NFPA-13.
- M. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded, comply with NFPA-13.
- N. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

- O. Victaulic Style 009H, 107H, and 07, Grinnell, or approved equal, rigid couplings may be used with IPS steel piping systems, which meet the support and hanging requirements of NFPA-13. An adequate number of Victaulic Style 177, 75, and 77, Grinnell, or approved equal, flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe.

2.3. VALVES

- A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer. All valves shall be provided with tamper switches and coordinated with Division 28.

2.4. PRESSURE GAUGES

- A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.
- B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.
- C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.
- D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.
- E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.5. ESCUTCHEONS

- A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.
- B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.6. DIELECTRIC CONNECTIONS:

- A. Furnish and install electrically insulated dielectric waterway fittings, unions or flanges, as manufactured by EPCO Sales, Inc., or Victaulic Co. at the following locations:
 - 1. Where steel piping systems join copper piping.

2. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.

2.7. SLEEVES

- A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.
- B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend $\frac{3}{4}$ -inch above the floor. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.
- C. Sleeves through walls and floors shall be sealed with with a waterproof caulking compound.
- D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.8. WATER PROOF PIPE PENETRATION SEALS

- A. Provide and install waterproof pipe penetration seals at all pipes that enter the building below grade or through exterior wall.
- B. Link seals are to be Metraflex Metraseals, Model MS, Linkseal, or approved equal, black EPDM seal material, glass reinforced plastic pressure plates, zinc plated nuts and bolts, seals are to be resistant to sunlight and ozone, pressure rated to make a hydrostatic seal of up to 20 psig and up to 40 feet of head, temperature rated from -40 degrees F to 250 degrees F.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

- A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the

piping at connections to all items of equipment, and installed so that there will be no interference with the installation of the equipment. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.

- B. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.
- C. All valves and other fittings shall be readily accessible.
- D. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.
- E. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.
- F. Install all valves with stem upright or horizontal, not inverted.
- G. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.
- H. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.
- I. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.
- J. Where zone valve assemblies are installed in stairwells, install primed and painted 18 gauge removable mesh screen. Color of paint shall be as selected by Architect.

3.2. PRESSURE GAGE INSTALLATION REQUIREMENTS.

- A. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.
- B. Adjust faces of gages to proper angle for best visibility.
- C. Clean windows of gages and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion.

Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

- C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.
- F. Do not attempt to repair defective valves; replace with new valves.
- G. Install valves as indicated, according to manufacturer's written instructions.
- H. Piping installation requirements are specified in other Division 21 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.
- I. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.
- J. Locate valves for easy access and provide separate support where necessary.
- K. Install valves in horizontal piping with stem at or above the center of the pipe.
- L. Install valves in a position to allow full stem movement.
- M. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

3.4. PIPE JOINTS INSTALLATION REQUIREMENTS

- A. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.
- B. Grooved Joints: Install in accordance with the manufacturer's (Victaulic, Grinnell, or approved equal) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.
- C. Soldered Joints and Copper Piping: Joints in copper piping shall conform to the following

minimum standards.

1. The pipes shall be cut to a length making certain that the ends are square, using a fine hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.
 2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.
 3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.
 4. The correct amount of solder per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.
 5. Solder joints shall be made by using a direct flame from a torch.
 6. On pipe sizes larger than 1/4-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the solder starts to melt to insure an even distribution of the solder.
 7. The excess solder shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.
 8. Solder joints shall be suitable for working pressure of 100 psig and for working temperature of not less than 250 degrees F. The type of solder and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.
- D. Where copper piping joins steel piping, approved bronze adapters shall be used.
- E. Prohibited Connections: No direct weld, soldered, or brazed connections, without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

3.5. HANGERS AND SUPPORTS INSTALLATION REQUIREMENTS

- A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal. Comply with NFPA-13.
- B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping.
- C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support.

All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.

- D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.
- E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.
- F. Select hangers and components for loads imposed. Secure rods with double nuts.
- G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.
- H. Support overhead piping with clevis hangers.
- I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.
- J. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.
- K. Construct concrete anchors of poured in place concrete of dimensions indicated and include embedded fasteners.
- L. Refer to structural documents for appropriate connection/attachment materials to building.

3.6. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS

- A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.
- B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
$\frac{1}{2}$ to 1 $\frac{1}{4}$	8	$\frac{1}{2}$

1-½ to 2	8	¾
2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.7. VALVE IDENTIFICATION REQUIREMENTS

- A. All valves shall be tagged with a numbered tag.
- B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.
- C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.
- D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in the main fire protection riser room. Additional copies shall be provided in each copy of the O&M manuals.

END OF SECTION

DIVISION 21 SECTION 211003
WATER BASED FIRE SUPPRESSION SYSTEM – SPRINKLER & STANDPIPES
TABLE OF CONTENTS

PART 1. GENERAL	1
1.1. REFERENCE.....	1
1.2. DESCRIPTION.....	2
1.3. DELIVERY, STORAGE AND PROTECTION	3
1.4. EXTRA MATERIALS.....	3
1.5. PERMITS FROM THE AUTHORITY HAVING JURISDICTION AND FEES	3
1.6. HYDRANT FLOW TESTS	3
1.7. ALTERNATES	4
PART 2. PRODUCTS.....	4
2.1. SPECIALTIES	4
2.2. SPRINKLER HEADS.....	5
2.3. FLEXIBLE SPRINKLER DROPS	6
2.4. SIGNS	7
2.5. DRAINS.....	7
2.6. ALARM DEVICES	7
2.7. GAUGES	8
2.8. VALVES.....	8
2.9. STANDPIPE HOSE VALVES	8
2.10. STANDPIPE VALVE CABINETS	8
PART 3. EXECUTION.....	9
3.1. GENERAL INSTALLATION REQUIREMENTS	9
3.2. INTERFACE WITH OTHER PRODUCTS.....	10
3.3. STANDPIPE AND HOSE VALVE INSTALLATION REQUIREMENTS.....	10
3.4. LAYOUT	10
3.5. WET PIPE SPRINKLER SYSTEM.....	11
3.6. VALVE INSTALLATION	11
3.7. CONNECTIONS	11
3.8. COMMISSIONING.....	11
3.9. DRAINS.....	12
3.10. TESTS.....	12
3.11. AS-BUILT DRAWINGS & PROJECT CLOSEOUT	12
3.12. WARRANTY	12
3.13. OWNER TRAINING.....	12
END OF SECTION	13

SECTION 21 10 03

WATER BASED FIRE SUPPRESSION SYSTEM - SPRINKLERS & STANDPIPES

PART 1. GENERAL

1.1. REFERENCE

- A. The conditions of the Contract and General Requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 21 Section, Common Work Results for Fire Protection and Division 01 Section, General Requirements.
- B. Submit complete shop drawings of all equipment utilized with the system in accordance with Division 21 Section, Common Work Results for Fire Protection. Submittals shall include but not be limited to the following fire protection system and accessories:
 - 1. Ball Drip Valves
 - 2. Pressure Sensing Devices, Valves
 - 3. Alarm Check Valves
 - 4. Pressure/Vacuum Gauges
 - 5. Inspector's Test Station
 - 6. Eccentric Reducers
 - 7. Pressure Switches
 - 8. Valves and Piping
 - 9. Standpipe Valves
 - 10. Flow Switches
 - 11. Tamper Switches
 - 12. Hose Valve Cabinets
 - 13. Auxiliary Drains
- C. Provide sprinklers, piping and associated equipment complete and ready for operation. Equipment materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with NFPA-13, NFPA-70, NFPA-14, NFPA-72E, and NFPA-101. Devices and equipment for fire protection service shall be U.L listed or FM approved.
- D. All of the equipment and devices shall be included within the project Operations and Maintenance Manuals.

- E. Refer to Division 21 Section, Fire Protection Pipes, Valves, and Fittings for pipe materials.
- F. Fire Protection Systems design, equipment and installation shall comply with the Delaware State Fire Prevention Regulations, latest edition including all Annexes and Addendums.

1.2. DESCRIPTION

- A. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the work specified in this Section and as shown on the drawings. The work shall be performed by a licensed sprinkler contractor only. All equipment, piping, devices, and valves shall be sized based on hydraulic calculations. Include a 10 psig safety factor with hydraulic calculations.
- B. Layout sprinkler system complete and size all fire protection piping in accordance with requirements of the National Fire Protection Association and the State Fire Marshal. System shall be designed for occupancy as required by applicable codes. Conceal fire protection piping in finished spaces unless indicated otherwise. System drains and inspector's test shall not be located in finished spaces.
- C. Sprinkler equipment and work shall conform to requirements of National Fire Protection Association Standard No. 13, No.14, and No. 24. In addition, all work shall conform to requirements of all codes and regulations of authorities having jurisdiction over this work, including, but not limited to, State Fire Marshal, County Fire Marshal, Life Safety Codes and International Code, and Insurance Underwriter.
- D. Preliminary Shop Drawing: Prior to preparing detailed working drawings for submission to State Fire Marshal, submit preliminary sprinkler system layout to the Architect for review and approval. Show all finished ceilings, light fixtures, air diffusers and other ceiling mounted devices. Coordinate sprinkler head types and locations with ceiling types. All sprinkler heads in acoustic tile ceilings shall be centered in the tile.
- E. The fire protection contractor shall prepare dimensioned and detailed working drawings, specifications, and hydraulic calculations and submit same to the State Fire Marshal and/or County Fire Marshal for review and approval. Prior to submission to the Fire Marshal, the Fire Protection Contractor shall have all fire protection drawings, submittals, calculations reviewed and approved by a registered Fire Protection Engineer or a level III Nicet Technician. One set of these approved documents shall be provided to the Engineer for record purposes. All costs related to changes required to obtain the Fire Marshal's or Insurance Underwriters' approval shall be the responsibility of the contractor.
- F. Manufactured equipment and materials shall be submitted to the Engineer for review and approval, in accordance with the requirements of Division 21 Section, Common Work Results for Fire Protection.
- G. Hydraulic calculations should be based on an available water supply from existing firepump as follows:

Horsepower =	25 HP
Pressure Differential =	75 psig
Flow =	400 gpm

Location =	Fire pump room
------------	----------------

- H. Hydraulic calculations shall include a 10 psig safety factor to account for pipe aging and deterioration of water supply.
- I. For small areas subject to freezing (loading dock, exterior canopy, etc.), Contractor shall provide and install freeze proof heads, piping, control valves, tamper switches, test stations, etc., as required by NFPA-13 and the authority having jurisdiction. Where combustible construction materials are located above ceilings, provide above ceiling fire protection in accordance with N.F.P.A-13.

1.3. DELIVERY, STORAGE AND PROTECTION

- A. Refer to Division 01 Section, General Requirements: Transport, handle, store, and protect products.
- B. Accept equipment and devices on site in factory packing. Inspect for damage. Comply with manufacturer's rigging and installation instructions for all equipment.
- C. Protect components from physical damage including effects of weather, water, and construction debris.
- D. Provide temporary inlet and outlet caps, and maintain in place until installation.

1.4. EXTRA MATERIALS

- A. Provide extra sprinklers under provisions of NFPA-13. Provide suitable wrenches for each sprinkler type and metal storage cabinet.

1.5. PERMITS FROM THE AUTHORITY HAVING JURISDICTION AND FEES

- A. Pay all permits, fees, and charges required for this work.

1.6. HYDRANT FLOW TESTS

- A. The Fire Protection Contractor shall perform a hydrant flow test.
- B. The hydrant flow test shall be performed by the Fire Protection Contractor in the vicinity of each building at no additional cost to the Owner.
- C. Where practical, tests shall be performed between 9:00 a.m. and 5:00 p.m. on a normal working day during summer. If conducting the test is impractical during these hours, then a local Fire Department representative shall be present to "observe" the test during "off peak" hours and to acknowledge the correctness of results.
- D. The tests shall be submitted for review prior to submitting any hydraulic calculations. The test data shall contain the following:
 - 1. Date of the test

2. Who performed the test and who was present.
3. Site plan indicating locations and diameters of water mains and locations of the hydrants tests.
4. Grade elevation of the hydrant tests
5. Static pressure in psig
6. Flow in GPM
7. Residual pressure in psig
8. Hydrant butt size in inches
9. Hydrant coefficient

1.7. ALTERNATES

- A. Refer to Division 01 Section, Alternates - Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. SPECIALTIES

- A. All sprinkler heads shall be U.L. listed and shall be of the same manufacturer throughout the building.
- B. Piping shall be in accordance with Division 21 Section, Fire Protection Piping, Fittings, and Valves, etc. All exposed fire protection piping in unfinished areas shall be painted with red epoxy paint. White letters shall identify piping and indicate direction of flow. Exposed fire protection piping within finished areas shall be painted in color as determined by the Architect/Engineer.
- C. Shut-off valves shall be UL approved O.S. and Y. double disc gate valves or UL/FM approved grooved end butterfly valves.
- D. Check valves shall be swing check type or spring-loaded type UL approved for the application.
- E. Coordinate the fire protection systems with the fire alarm system specified under Division 26. Provide alarm initiating devices with proper contact arrangement. All electrical wiring shall be furnished and installed under Division 26.
- F. Flow control valve, alarm switches and valve supervision shall be furnished and installed under this Division. All wiring shall be accomplished by the electrical contractor, under Division 26. Provide any additional flow control valves, alarm switches, tamper switches and flow switches required by NFPA-13 and NFPA-14, but not indicated on contract drawings. Coordinate with the alarm system and electrical subcontractor.
- G. Pipe and fittings shall meet the requirements of NFPA 13, NFPA-14, and NFPA-24.

- H. Wet pipe alarm check valve shall be Victaulic FireLock Series 750, or approved equal. Valve shall be UL listed and FM approved for sprinkler systems with 175 psig maximum working pressure. Provide complete valve trim package including all necessary valves, gauges, fittings, nipples and alarm test. Valve internal components shall be replaceable without removing the valve from the installed position. Valve shall be installed in the vertical position only.

2.2. SPRINKLER HEADS

A. Suspended or Drywall Ceilings:

1. Manufacturer: Victaulic, Viking, Grinnell, Reliable, or approved equal.
2. All sprinkler heads installed in suspended ceilings and drywall ceilings including bulkheads shall be Victaulic Model V38 concealed quick response sprinkler or approved equal. Cover plate shall be finished with a polyester baked enamel finish. Color selection by Architect. Provide cover assembly with each head. Frangible glass bulb shall be temperature rated for specific area hazard.
3. Sprinkler heads in all other areas with finished ceilings shall be Victaulic Model V27 or approved equal. These sprinklers shall be standard pendant type with matching screw on escutcheon plate. Sprinkler and escutcheon plate finish shall be chrome plated. Fusible link shall be temperature rated for specific area hazard.

B. Exposed Area Type:

1. Manufacturers: Victaulic, Viking, Grinnell, Reliable, or approved equal.
2. Sprinkler heads in unfinished or exposed areas shall be Victaulic Model V27, or approved equal. These sprinklers shall be standard, ½ inch upright, pendant or conventional where required. Provide guards where hereinafter indicated. Sprinklers shall be brass with frangible glass bulb temperature rated for specific area hazard. Provide standard brass, screw on flat escutcheon plate.

C. Sidewall type:

1. Manufacturers: Victaulic, Viking, Grinnell, Reliable, or approved equal.
2. Sidewall sprinklers shall be Victaulic Model V27 semi-recessed horizontal sidewall type with matching screw on escutcheon plate. Sprinkler and escutcheon plate finish shall be chrome plated. Frangible glass bulb shall be temperature rated for specific area hazard.

D. Dry Sprinklers:

1. Manufacturers: Victaulic, Viking, Grinnell, Reliable, or approved equal.
2. Sprinkler heads for areas subject to freezing (walk-in boxes), small loading docks, small canopies, and similar spaces shall be Victaulic Model V36 dry sprinkler or approved equal. Dry sprinkler shall be standard or expose pendant type with matching escutcheon plate. Sprinkler and escutcheon plate shall be chrome plated.

Frangible glass bulb shall be temperature rated for specific area hazard. Length of heads shall be as required to suit field conditions. Provide adjustable surface mounted escutcheon plate with each head. Provide flush ceiling plate.

- E. Quick Response Type:
 - 1. Manufacturers: Victaulic, Viking, Grinnell, Reliable or approved equal.
 - 2. Sprinkler heads, shall be listed quick response sprinklers in accordance with NFPA-13 and NFPA-101. Quick response sprinklers shall be Victaulic Model V27 or approved equal. Model and deflector style shall be as required to accommodate upright, pendant, sidewall or recessed mounting. Sprinklers and escutcheon plates shall be chrome plated. Frangible glass bulb shall be temperature rated for specific area hazard.
- F. The temperature rating of the sprinklers shall be as required by N.F.P.A.-13 and or the authority having jurisdiction.
- G. All sprinkler heads installed in lay-in ceiling tiles shall be located in the center of the tile to provide a symmetrical, aesthetic and neat appearance. All sprinkler heads installed in bulkheads, recesses, and soffits shall be centered to provide a symmetrical, aesthetic and neat appearance.
- H. Provide extended escutcheons in rooms with surface mounted lighting fixtures.
- I. Additional heads shall be furnished as required by NFPA-13. The heads shall be in a cabinet designed to hold the heads and include one sprinkler head wrench for each type of sprinkler. Cabinet shall be mounted where indicated in the field.
- J. Head guards shall be provided in mechanical spaces, penthouses, janitors' closets, electrical rooms, storage areas, elevator shafts, and elevator machine rooms. Finish for head guards in finished spaces shall be selected by Architect.
- K. Sprinkler escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler, by the sprinkler manufacturer.
- L. Provide high temperature sprinkler heads for use adjacent to skylights, heaters, lights, or other high temperature areas.

2.3. FLEXIBLE SPRINKLER DROPS

- A. Stainless Steel Sprinkler Fittings
 - 1. Manufacturer: Victaulic AquaFlex®
 - 2. In lieu of rigid pipe offsets for concealed locations only, or return bends for sprinkler drops, the Victaulic AquaFlex® stainless steel, multiple-use, sprinkler fitting system may be used to locate sprinklers as required by final finished ceiling tiles and walls. The drop system shall consist of a braided or unbraided (corrugated) type 304 stainless steel flexible tube, a zinc-plated steel 1" NPT male threaded nipple for connection to branch-line piping, and a zinc-plated steel

reducer with ½" or ¾" NPT female thread for connection to the sprinkler head. Union joints shall be provided for ease of installation. The flexible drop shall attach to the ceiling grid using a one-piece open gate bracket. The braided drop system is FM approved for sprinkler services to 200 psi and can be installed without the use of tools, and the unbraided system is UL listed for sprinkler services to 175 psi.

2.4. SIGNS

- A. Provide 9 inch x 7 inch signs suspended from control valves which indicate the purpose of the valve and its normal position, Central Type A or approved equal.
- B. All control, drain, and test connection valves shall be provided with signs indicating purpose.
- C. Signs shall be fabricated of an approved material, painted red with white lettering.
- D. Signs shall have typed labels. Handwritten labels shall not be acceptable.

2.5. DRAINS

- A. The sprinkler systems shall be arranged to be completely drainable. Means of drainage shall be provided with adequate protection from freezing.
- B. Drain valve may be combined with sprinkler alarm test valve and sight glass, G/J Innovations Sure-Test or approved equal. Valve shall be UL listed with positive off handle for off, test or drain, integral sight glass, orifice size equal to smallest sprinkler orifice and full 1 inch drain.

2.6. ALARM DEVICES

- A. Approved water flow switches shall be installed to activate the fire alarm, and annunciate sprinkler flow at a minimum on each floor, each system riser, elevator shaft, where indicated on the contract documents and where required by N.F.P.A. or the authority having jurisdiction. Conductors shall be provided under the electric division to provide fire alarm, and annunciation. Activation of the sprinkler system by one sprinkler or equivalent test shall cause the fire alarm system to activate, and the appropriate lamp(s) to activate on the annunciator. An approved test shall be provided for each water flow switch.
- B. All valves controlling water supply for sprinklers shall be electrically supervised in accordance with requirements of NFPA 13 and 72A, and provided under this Division. Provide separate valve chart for all fire protection valve indicating valve type, normal position, size, location and type of supervision insert in O&M manual and mount additional copies in fire pump room and mechanical rooms.
- C. Valve tamper switches shall be Model OSY2 as manufactured by System Sensor or Model OSYSU-A2 as manufactured by Potter Electric Signal Company or approved equal. The valve tamper switches shall monitor the open position of all OS&Y gate valves. Each tamper switches shall contain two sets of single pole double throw, Form C contacts. All valve tamper switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Tamper switches shall be suitable for 125/250 VAC @

15 AMPS. All tamper switches shall be U.L. listed and F.M. approved.

- D. Pressure type flow switches shall be Model EPS10 as manufactured by System Sensor or Model PS10-2 as manufactured by Potter Electric Signal Company or approved equal. Each pressure type flow switch shall contain two sets of single pole double throw switch contacts. All pressure type flow switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Pressure type flow switches shall be suitable for 125/250 VAC @ 10 AMPS. All pressure type flow switches shall be U.L. listed and F.M. approved.
- E. Vane Type waterflow switch with retard shall be WFD Series as manufactured by System Sensor or Model VSR-F as manufactured by Potter Electric Signal Company or approved equal. The VAC type waterflow switches shall contain two single pole, double throw form C, snap return switches. All Vane type waterflow switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Vane type waterflow switches shall be suitable for 125/250 VAC @ 10 AMPS. All vane type waterflow switches shall be U.L. listed and F.M. approved.

2.7. GAUGES

- A. A listed 3 ½ inch dial spring pressure gauge shall be connected to the top of each standpipe. Gauges shall be located in a suitable place to prevent freezing. Each gauge shall be controlled by a valve having arrangement for draining.
- B. Listed pressure gauges with connections not smaller than ¼ inch shall be installed at the system main drain, at each main drain associated with a floor control valve, and above and below each alarm check-valve.
- C. All pressure gauges shall be listed and shall have a maximum limit not less than twice the normal working pressure at the point where installed. They shall be installed to permit removal and shall be located where they will not be subject to freezing.

2.8. VALVES

- A. Provide and install control valves as indicated on contract drawings and as required by N.F.P.A.-13, and N.F.P.A.-14. Gate valves shall be listed O.S. & Y. type. All control valves shall be supervised open. Supervision shall be as required by N.F.P.A.-13. Victaulic Series 705 and 765 grooved end butterfly valves shall be supervised in the open position.

2.9. STANDPIPE HOSE VALVES

- A. Standpipe angle valve shall be Potter Roemer 4020 series, Class I, 2½ inch angle valve, brass body, brass mounting, inside screw rising stem, red handle, cap and chain, pressure regulating up to 100 psig inlet pressure. Match threads to local fire department.

2.10. STANDPIPE VALVE CABINETS

- A. Valve cabinets shall be fully recessed, Potter Roemer, 20 gauge steel cabinet, white polyester finish with continuous hinge, steel door with glass. Standpipe valve cabinets shall be rated for installation in stairwell, fire rated wall. Valve cabinet locks shall match

requirements of local Fire Department keys. Keys shall be located in exterior lock box. Coordinate with local Fire Department.

- B. Pressure regulating fire department valve cabinet shall be the 1800 series as manufactured by Potter-Roemer, Larsens or approved equal.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

- A. Install equipment in accordance with manufacturer's instructions.
- B. Place pipe runs to minimize obstruction to other work.
- C. Place piping in concealed spaces above finished ceilings.
- D. Center sprinklers in two directions in ceiling tile and provided piping offsets as required.
- E. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.
- F. Flush entire piping system of foreign matter.
- G. Install guards on sprinklers where subject to abuse and where specified.
- H. Hydrostatically test entire system.
- I. Test must be witnessed by Fire Marshal/authority having jurisdiction/ Owner's insurance underwriter/ Architect/Engineer.
- J. Refer to plumbing floor plans for approximate locations of sprinkler zones control valve assemblies and routing of fire protection mains.
- K. Locate inspectors test stations for sprinkler zones per NFPA-13. Provide and install drain piping from all approved terminations. Provide splash blocks for terminations outside. Splash block locations shall be approved by the Architects.
- L. The fire protection contractor shall hydraulically prove the most remote area per NFPA-13.
- M. Coordinate locations of sprinkler heads with lights, diffusers, ceiling types, etc.
- N. Hydrostatically test system at 200 PSI for 4 hours, per NFPA-13.
- O. The sprinkler bulb protector must remain in place until the sprinkler is completely installed and before the system is placed in service. Remove bulb protectors carefully by hand after installation. Do not use any tools to remove bulb protectors.
- P. Refer to Architectural Drawings for exact location and extent of all fire rated walls and smoke barriers.

- Q. Sprinkler shall be provided at top and bottom of the elevator shaft as per NFPA-13, latest edition.
- R. A separate control valve with tamper switch shall be installed for the top and bottom of the elevator shaft and elevator machine room.
- S. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing.

3.2. INTERFACE WITH OTHER PRODUCTS

- A. Ensure required devices are installed and connected as required to fire alarm system.

3.3. STANDPIPE AND HOSE VALVE INSTALLATION REQUIREMENTS

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NFPA-14.
- C. Locate and secure cabinets plumb and level. Establish top of cabinet surface 66 inches above finished floor.
- D. Locate hose station valve in cabinet at 60 inches above floor. Locate hose connection valve below hose station valve and not closer than 4 inches from side or bottom of cabinet.
- E. Where static pressure exceeds 100 psi but is less than 100 psi at any hose station, provide pressure orifice disc in discharge of hose station valve to prevent pressure on hose exceeding 90 psi.
- F. Where static pressure exceeds 100 psi at any hose station, provide pressure reducing valve to prevent pressure on hose exceeding 90 psi.
- G. Where required by Code or Fire Marshal, provide two way fire department outlet connection on roof. Protect against freezing.
- H. Flush entire system of foreign matter.
- I. Install control valves on each standpipe riser and pressure gauges at the top of each standpipe.

3.4. LAYOUT

- A. Coordinate layout and installation of fire protection system with all other buildings structural, mechanical and electrical work. Locate sprinkler heads symmetrically with respect to ceiling tiles, lighting fixtures, registers, grilles, diffusers, etc. Provide piping offsets as required to maintain symmetry. Note that a preliminary sprinkler layout is to be submitted for review. Contractor is cautioned that sprinkler mains must be located to

prevent conflict with other work and in any case, sprinkler contractor shall be responsible for coordination of his work with work of other trades.

- B. Unless otherwise indicated, the entire building shall be protected throughout with a wet pipe sprinkler system.

3.5. WET PIPE SPRINKLER SYSTEM

- A. System components shall include, but not be limited to flow control valves, electrical connections to central fire alarm system, check valves, main piping, branch piping, inspector's test, drains, sprinkler heads, hose valves and cabinet, ball drip valves, signs, standpipes, etc. and all other incidental appurtenances as required.

3.6. VALVE INSTALLATION

- A. Gate Valves: Install fire-protection-service valves supervised-open, located to control sources of water supply except from fire department connections. Provide permanent identification signs indicating portion of system controlled by each valve.
- B. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.
- C. Alarm Check Valves: Install valves in vertical position for proper direction of flow, including bypass check valve and retard chamber drain-line connection.

3.7. CONNECTIONS

- A. Connect water supplies to standpipes and sprinklers.
- B. Connect piping to specialty valves, specialties, fire department connections, and accessories.
- C. Connect alarm devices to fire alarm.

3.8. COMMISSIONING

- A. Verify that specialty valves, trim, fittings, controls, and accessories are installed and operate correctly.
- B. Verify that specified tests of piping are complete.
- C. Verify that damaged sprinklers and sprinklers with paint or coating not specified are replaced with new, correct type.
- D. Verify that sprinklers are correct types, have correct finishes and temperature ratings, and have guards as required for each application.
- E. Verify that potable-water supplies have correct types of backflow preventers.
- F. Verify that fire department connections have threads compatible with local fire department equipment

- G. Fill wet-pipe sprinkler piping with water.
- H. Energize circuits to electrical equipment and devices.
- I. Adjust operating controls and pressure settings.
- J. Coordinate with fire alarm tests. Operate as required.

3.9. DRAINS

- A. The sprinkler system shall be arranged to be completely drainable. Means of drainage shall be provided with adequate protection from freezing.

3.10. TESTS

- A. The sprinkler systems installation shall be hydrostatically tested, inspected, and approved, in accordance with NFPA Standard No. 13, NFPA Standard No. 14, and NFPA Standard No. 25. Test certificate shall be forwarded to the Office of the State Fire Marshal and the Architect as proof of compliance.
- B. Tests shall be performed in accordance with the requirements of the Office of the State Fire Marshal and shall prove the systems to be adequate and satisfactory in every respect. All tests shall be performed in the presence of the State Fire Marshal or his representative.
- C. Any deficiencies revealed by these tests shall be corrected and the systems shall be retested until acceptable results are obtained.

3.11. AS-BUILT DRAWINGS & PROJECT CLOSEOUT

- A. Provide separate as-built drawings of all fire protection systems meeting requirements of General Mechanical Requirements hereinbefore specified.
- B. At the completion of the work, provide a sealed plan of the building indicating the locations of all control valves, low point drains, flow switches, and Inspectors Test Stations. The plan shall be neatly drawn and color coded to indicate the portion of the building protected by each system, framed under glass and permanently mounted on the wall adjacent to the system header.
- C. Include manufacturers literature, cleaning procedures, replacement parts, lists, and repair data for equipment.
- D. Include manufacturers' instructions, start-up data, troubleshooting, check lists for all equipment.

3.12. WARRANTY

- A. The Contractor's attention is directed to the warranty obligations contained in the Article of the General Conditions of the specifications entitled "warranty".

3.13. OWNER TRAINING

- A. Upon completion of the project, furnish a complete copy of NFPA-25 to Owner. Provide

correspondence indicating that the pamphlet has been turned over to the Owner.

1. Contractor shall provide at least eight (8) hours of training to the Owner on the proper inspection, testing, and maintenance of the installed fire protection system.
2. Schedule training with the Owner through the Architect and/or Engineer with at least seven (7) days prior notice.
3. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

END OF SECTION

DIVISION 22 SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING
TABLE OF CONTENTS

PART 1. GENERAL.....	3
1.1. SUMMARY	3
1.2. PERMITS AND FEES	3
1.3. EXAMINATION OF SITE	3
1.4. CONTRACTOR QUALIFICATION.....	4
1.5. MATERIALS AND EQUIPMENT	4
1.6. FIRE SAFE MATERIALS.....	5
1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS	5
1.8. SUBMITTALS, REVIEW AND ACCEPTANCE.....	5
1.9. SHOP DRAWINGS	6
1.10. SUPERVISION AND COORDINATION.....	8
1.11. CUTTING AND PATCHING	9
1.12. PENETRATION OF WATERPROOF CONSTRUCTION.....	9
1.13. CONCRETE AND MASONRY WORK	10
1.14. CONNECTIONS AND ALTERATIONS TO EXISTING WORK	10
1.15. DEMOLITION	10
1.16. EXCAVATION AND BACKFILLING	12
1.17. ALTERNATES.....	13
1.18. DEFINITIONS.....	13
1.19. MINIMUM EFFICIENCY REQUIREMENTS	13
1.20. SYSTEM INTEGRATION.....	14
1.21. LEAD FREE REQUIREMENTS.....	14
PART 2. ELECTRICAL REQUIREMENTS	14
2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS	14
2.2. MOTORS AND CONTROLS	15
2.3. MOTOR INSTALLATION	17
2.4. WIRING DIAGRAMS	18
PART 3. EXECUTION.....	18
3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS.....	18
3.2. SUPPORTS, HANGERS AND FOUNDATIONS	18
3.3. DEMONSTRATION AND TRAINING VIDEO RECORDINGS	19
3.4. PROVISIONS FOR ACCESS	19
3.5. PAINTING AND FINISHES.....	20
3.6. CLEANING OF SYSTEMS	20
3.7. COLOR SELECTION	21
3.8. PROTECTION OF WORK.....	21
3.9. OPERATION OF EQUIPMENT	21
3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS.....	22
3.11. WALL AND FLOOR PENETRATION	22
3.12. RECORD DRAWINGS	23
3.13. WARRANTY	23
3.14. OPERATIONS AND MAINTENANCE MANUALS.....	24
3.15. INSTALLATION AND COORDINATION DRAWINGS	25

3.16. PIPING SYSTEMS TESTING	25
3.17. EQUIPMENT BY OTHERS.....	26
3.18. OUTAGES.....	26
END OF SECTION	27

SECTION 22 05 00**COMMON WORK RESULTS FOR PLUMBING****PART 1. GENERAL****1.1. SUMMARY**

- A. All work under Division 22 is subject to the Division 01, General Requirements, the General Conditions and Supplementary Conditions.
- B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all plumbing work.
- C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.
- D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, piping, up to the time of rough-in or fabrication.
- E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.
- F. Coordinate the work under Division 22 with the work of all other construction trades.
- G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

- A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.
- B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

- A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for contractors failure to do so.
- B. Examine and verify specific conditions described in individual specifications sections.

- C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

- A. Any Contractor or Subcontractor performing work under Division 22 shall be fully qualified and acceptable to the Architect and Owner. Submit the following evidence when requested:
 - 1. A list of not less than five comparable projects which the Contractor completed.
 - 2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.
 - 3. Local and/or State License, where required.
 - 4. Membership in trade or professional organizations where required.
- B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.
- C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

- A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality. Existing items of equipment are being relocated under another Division of these specifications. The Contractor shall be responsible for connecting all utilities as shown on the drawings, to equipment identified as existing.
- B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.
- C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.
- D. Substitution will not be permitted for specified items of material or equipment where noted.
- E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

- A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

- A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.
- B. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
- C. ASME - American Society of Mechanical Engineers
- D. ASPE - American Society of Plumbing Engineers
- E. ASTM - American Society for Testing and Materials
- F. AWWA - American Water Works Association
- G. CS - Commercial Standard
- H. DNREC - Delaware Department of Natural Resources and Environmental Control
- I. FM - Factory Mutual
- J. IBC - International Building Code
- K. IEEE - Institute of Electrical and Electronics Engineers
- L. MSSP Industry - Manufacturers Standards Society of the Valve and Fittings
- M. NEC - National Electrical Code
- N. NEMA - National Electrical Manufacturers Association
- O. NSF - National Sanitation Foundation
- P. UL - Underwriters' Laboratories
- Q. All plumbing equipment and materials shall comply with the codes and standards listed in the latest edition of ASHRAE HVAC Applications Handbook, Chapter entitled Codes and Standards.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

- A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or

materials except where such substitution is considered by the Architect to be in best interest of Owner.

- B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.
- C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.
- D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.
- E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.
- F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.
- G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.
- H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.
- I. For resubmissions, the Contractor must address in writing all of the Engineer's comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

- A. Prepare and submit shop drawings for all plumbing equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.
- B. Submit data and shop drawings including but not limited to the list below, in addition to

provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.

- C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.
- D. Items and Systems
 - 1. Access Doors/Panels including layout and location
 - 2. Automatic Temperature Control System and Equipment as it relates to plumbing system
 - 3. Backflow Preventers
 - 4. Coordinated Drawings
 - 5. Direct Buried Piping
 - 6. Drain Valves
 - 7. Drip Pans
 - 8. Elevator Sump Pumps
 - 9. Equipment Rails
 - 10. Exterior Equipment/Piping Supports
 - 11. Exterior Pipe Roller Support
 - 12. Fire Stopping - Methods and Materials
 - 13. Floor and Roof Drains
 - 14. Gas Flexible Hoses
 - 15. Gas Pressure Regulating Valves
 - 16. Gas Quick Disconnect Valves
 - 17. Hose Bibbs and Wall Hydrants
 - 18. Identification System
 - 19. Material and Equipment List
 - 20. Operations and Maintenance Manuals
 - 21. Pipe Enclosures

22. Pipe Guides and Anchors.
 23. Pipe Materials Including Itemized Schedule
 24. Plumbing Fixtures & Trim
 25. Preliminary Testing and Balancing Report
 26. Pressure/Temperature Relief Valves
 27. Pressure Regulating Valves
 28. Pumps
 29. Roof Curbs
 30. Roof Drains
 31. Screenshots of ATC System Graphics
 32. Strainers
 33. Test Certificates
 34. Thermal Insulation Materials Include Table Summary
 35. Thermometers and Gauges
 36. Thermostatic Mixing Valves
 37. Trap Priming Station/Valves
 38. Vacuum Breakers
 39. Valves
 40. Vibration Isolation Materials
 41. Weatherproof Assembly Components
 42. Wiring Diagrams, Flow Diagrams and Operating Instructions
- E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.

1.10. SUPERVISION AND COORDINATION

- A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

- B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, equipment, and other work performed under Division 22.
- C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.
- D. Coordinate electrical work required under Division 22 with that under Division 26. Coordinate all work under Division 22 with work under all other Divisions.
- E. Supply services of an experienced (10 years minimum) and competent Project Manager to be in constant charge of work at site.
- F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.
- G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.
- H. Coordinate installation of large equipment requiring positioning before closing in building.

1.11. CUTTING AND PATCHING

- A. Accomplish all cutting and patching necessary for the installation of work under Division 22. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and workmanlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.
- B. Do not cut structural members without approval from the Architect or Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

- A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.
- B. Where plumbing vents or other pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.
- C. Furnish and install pitch pockets or weather tight curb assemblies where required.
- D. Furnish and install roof drains, curbs, and vent assemblies specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and

locations. All roof penetrations shall be installed in accordance with manufacturer's instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these specifications.

1.13. CONCRETE AND MASONRY WORK

- A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 22. Perform work in accordance with requirements of other applicable Divisions of these specifications.
- B. Concrete shall test not less than 3,000 psi compressive strength after 28 days.
- C. Grout shall be non-shrink, high strength mortar, free of iron of chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.

1.14. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

- A. Unless otherwise noted on the drawings, where existing plumbing work is removed all pipes, valves, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.
- B. Where work specified in Division 22 connects to existing equipment, piping, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.
- C. Where the work specified under Division 22, or under other Divisions, requires relocation of existing equipment, piping, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition. Where existing insulation is disturbed, replace insulation where removed or damaged equal to existing, in type, thickness, density, finish and thermal resistance (R-value) value.
- D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.15. DEMOLITION

- A. Unless otherwise noted all existing equipment, piping, etc., shall remain.
- B. Where existing equipment is indicated to be removed, all associated piping, conduit, power, controls, insulation, hangers, supports and housekeeping pads, etc., patch, paint and repair walls/roof/floor to match existing and/or new finishes.
- C. Provide necessary piping, valves, traps, temporary feeds, etc., as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time lengths of outages.

- D. The Contractor shall be responsible for visiting the site and determining the existing conditions in which the work is to be performed.
- E. Where any abandoned pipes in existing floors, walls, pipe tunnels, ceilings, etc., conflict with new work, remove abandoned pipes as necessary to accommodate new work.
- F. The location of all existing equipment, piping, etc., indicated is approximate only and shall be checked and verified. Install all new plumbing work to connect to or clear existing work as applicable.
- G. Maintain egress at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and the authorities having jurisdiction.
- H. When applicable, make provisions and include in bid all costs associated with confined entry/space requirements in crawl spaces, tunnels and all other applicable OSHA and MOSH regulations.
- I. Where required to maintain the existing systems in operation, temporarily backfeed existing systems from new equipment. Contractor shall temporarily extend existing piping systems to new piping systems with the appropriate shut-off valves.
- J. At completion of project all temporary piping, valves, controls, etc., shall be removed in their entirety.
- K. Existing piping, equipment, materials, etc., not required for re-use or re-installation in this project, shall be removed from the project site.
- L. Deliver to the Owner, on the premises where directed, existing equipment and materials which are removed and which are desired by the Owner or are indicated to remain the property of the Owner.
- M. All other materials and equipment which are removed shall become property of the Contractor and shall be promptly removed, from the premises, and disposed of by the Contractor, in an approved manner. Contractor shall be responsible for proper disposal of all removed equipment containing refrigerants. Contractor shall include in his bid all cost associated with the evacuation, removal and disposal of all existing equipment containing refrigerants in accordance with EPA and Health Department requirements.
- N. Where piping is removed, remove all pipe hangers which were supporting the removed piping. Patch the remaining penetration voids with like materials and paint to match existing construction.
- O. Where required, provide and coordinate removal and re-installation of existing equipment. Take care to protect materials and equipment indicated for reuse. Contractor shall repair or replace items which are damaged. Contractor shall have Owner's representative present to confirm condition of equipment prior to demolition.
- P. Before demolition begins, and in the presence of the Owners representative, test and note all deficiencies in all existing systems affected by demolition but not completely removed by demolition. Provide a copy of the list of system deficiencies to the Owner and the Engineer. Videotape existing conditions in each space prior to beginning demolition work.

- Q. The Owner shall have the first right of refusal for all plumbing fixtures, devices and equipment removed by the Contractor.
- R. All plumbing fixtures, devices and equipment designated by the Owner to remain the property of the Owner shall be moved and stored by the Contractor at a location on site as designated by the Owner. It shall be the Contractor's responsibility to store all plumbing fixtures, devices and equipment in a safe manner to prevent damage while stored.
- S. All existing equipment refused by the Owner shall become the property of the Contractor and shall be removed from the site by the Contractor in a timely manner and disposed of in a legal manner.
- T. Work Abandoned in Place: cut and remove underground pipe a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.
- U. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.
- V. Terminate services and utilities in accordance with local laws, ordinances, rules and regulations.

1.16. EXCAVATION AND BACKFILLING

A. GENERAL

- 1. Perform all necessary excavation, or installation of work under Division 22, in whatever materials or conditions encountered, using suitable methods and equipment.
- 2. Accurately establish required lines and grades and properly locate the work.
- 3. Determine the locations of all existing utilities before commencing the work.

B. Excavation: (Refer also to other portions of the specifications)

- 1. Excavate only the required elevations. If excavation is carried below the foundation lines or other required limits, backfill the excess with concrete.
- 2. Keep banks of trenches as nearly vertical as possible, and provide sheeting and/or shoring as required for protection of work and safety of personnel. Follow local, State, OSHA Guidelines.
- 3. Keep excavations dry. Protect excavations from freezing.

C. Backfilling: (Refer also to other portions of the specifications)

- 1. Backfill excavations to the required elevations and restore surfaces to their original or required conditions.
- 2. Backfill shall be similar material, free from objectionable matter such as rubbish, roots, stumps, brush, rocks and other sharp objects. Unless otherwise indicated, suitable material from the excavation may be used for backfill.

3. Carefully place and mechanically tamp backfill in layers not exceeding 12 inches loose thickness. Compact to 95 percent minimum.
4. Do not backfill against frozen material. Do not use frozen material for backfill.

1.17. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

1.18. DEFINITIONS

- A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.
- B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.
- C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.
- D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.
- E. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, or embedded in construction.
- F. Exposed means not installed underground or concealed as defined above.
- G. Invert Elevation means the elevation of the inside bottom of pipe.
- H. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceiling, unexcavated spaces, and tunnels.
- I. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.
- J. Building Line: Exterior wall of building.

1.19. MINIMUM EFFICIENCY REQUIREMENTS

- A. All plumbing equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.
- B. All piping and equipment insulation shall comply with ASHRAE Standard 90.1, latest edition.
- C. All plumbing devices, controls, accessories, and components shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

1.20. SYSTEM INTEGRATION

- A. For all plumbing equipment specified to be provided with packaged controls and interfaced with the automatic temperature control system, provide system integration between the equipment manufacturer and the automatic temperature control subcontractor.
- B. Plumbing equipment submittals requiring system integration as defined above must identify all required system integration points.
- C. Plumbing equipment manufacturers must coordinate with ATC subcontractor regarding system integration prior to submitting on the equipment.
- D. A system integration meeting must be arranged by the Mechanical Contractor and include, but not be limited to the systems integrator for the plumbing equipment manufacturer and the ATC Subcontractor. This portion of systems integration must occur prior to plumbing equipment being delivered to the project.
- E. Once the plumbing equipment is on site, a second systems integration meeting must be arranged by the Mechanical Contractor to coordinate the packaged controls with the ATC system. The plumbing equipment manufacturer's representative familiar with system integration and the ATC subcontractor familiar with programming must be present.
- F. A final system integrations meeting shall occur once all equipment is in place and ready for operation. The Mechanical Contractor, the plumbing equipment systems' integrator, and the ATC Subcontractor shall meet on site to jointly program, schedule, verify points, interlock devices, and fully set up all systems integration components.
- G. All systems integration coordination, programming, and graphics must be completed prior to requesting commissioning and/or inspections by the Engineer of Record.

1.21. LEAD FREE REQUIREMENTS

- A. All plumbing fixtures, equipment, and devices that contact potable water must be lead free per the State requirements. Potable water systems shall also comply with NSF 61 – Annex G and NSF-372.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

- A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 22 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 22. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 22.
- B. All electrical work performed under Division 22 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA & International

Building Code.

- C. Provide wiring diagrams with electrical characteristics and connection requirements.
- D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than five (5) horsepower.
- E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.
- F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.
- G. Motors located in exterior locations, wet air streams and outdoors shall be totally enclosed weatherproof epoxy-treated type.
- H. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.
- I. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.
- J. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

2.2. MOTORS AND CONTROLS

- A. Motors and controls shall conform to the latest requirements of IEEE, NEMA, NFPA-70 and shall be UL listed. Motor sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor is advised to consult all specification sections to determine responsibility for motors and controls.
- B. Motors shall be designed, built and tested in accordance with the latest revision of NEMA Standard MG 1.
- C. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.
 - 1. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating conditions. Under no condition shall the motor current exceed that indicated on the nameplates.
 - 2. Motor sizes noted in the individual equipment specifications are minimum

requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overloading, exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR2 of the driven equipment to operating speed.

3. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.
 4. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than ½ horsepower shall be single phase, and motors ½ horsepower and larger shall be 3 phase unless otherwise noted.
 5. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.
- D. Single phase motors, smaller than 1/20 horsepower shall be ball or sleeve bearing; drip-proof, totally enclosed or explosion proof, as specified; 120 volts; permanent-split capacitor or shaded pole type. These motors shall not be used for general power purposes, and shall only be provided as built-in components of plumbing equipment. When approved by the Engineer, deviations from the specifications will be permitted as follows:
1. Open motors may be installed as part of an assembly where enclosure within a cabinet provides protection against moisture.
 2. Motors used in conjunction with low voltage control systems may have a voltage rating less than 115 volts.
- E. Single phase motors, greater than 1/20 horsepower and less than ½ horsepower shall be ball bearing; drip-proof, totally enclosed or explosion proof, as specified, with Class A or B insulation, as standard with the motor manufacturer; 115 or 120/208/240 volts as required; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type with minimum efficiency of 70 percent and a minimum full load power of 77 percent.
- F. Except as otherwise specified in the various specification sections, 3 phase motors 60 horsepower and smaller shall be NEMA design B squirrel cage induction type meeting the requirements of this paragraph. Motors shall be drip-proof, totally enclosed or explosion proof, as specified or indicated. Insulation shall be Class B or F, at 40 degrees C ambient temperature. Drip-proof motors shall have a 1.15 service factor and totally enclosed and explosion proof motors shall have a service factor of 1.00 or higher. Motors specified for operation at 480, 240, and 208 volts shall be nameplated 460, 230, 200 volts, respectively. Efficiencies and percent power factor at full load for three phase motors shall be not less than the values listed below for premium efficiency motors:

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR

1HP and above to	85.5 percent	84 percent
1-½ HP	86.5 percent	85 percent
2HP	86.5 percent	85 percent
3HP	89.5 percent	86 percent
5HP	89.5 percent	87 percent
7½ HP	91 percent	86 percent
10HP	91.7 percent	85 percent
15HP	93.0 percent	85 percent
20HP	93.0 percent	86 percent
25HP	93.6 percent	85 percent
50HP	94.5 percent	88 percent
60 HP	95.0 percent	90 percent
75HP	95.0 percent	90 percent
100 HP	95.4 percent	90 percent
125 HP	95.8 percent	95 percent
150 HP and above	96.0 percent	95 percent

- G. Three phase motors ½ HP or greater shall be the Duty Master XE by Reliance Electric Company, Super-E Premium Efficiency of Baldor Motor and Drives, E-plus Efficient Standard Duty Motor of the Electric Motor Division of Gould, Inc., the MAC II High Efficiency motor of Westinghouse Electric Corp., the equivalent product of General Electric, or approved equal.
- H. For motors serving equipment being controlled by a variable speed drive, motor shall be premium efficiency inverter duty rated.
- I. Motor frames shall be NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast-iron or aluminum with steel inserts.
- J. Control of each motor shall be manual or automatic as specified for each in the various mechanical sections. In general, and unless otherwise specified for a particular item in the various mechanical sections of the specifications, motor starters and controls shall be specified and provided under the various electrical sections of these specifications.

2.3. MOTOR INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors to support shaft regardless of shaft position.
- C. Check line voltage and phase and ensure agreement with nameplate. Check that proper

thermal overloads have been installed prior to operating motors.

2.4. WIRING DIAGRAMS

- A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.
- B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.
- C. Provide wiring diagrams for all major plumbing items of equipment to electrical contractor and ATC subcontractor for coordination.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.
- B. Install equipment according to approved submittal data. Portions of the work are shown only in diagrammatic form. Refer conflicts to the Architect.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- E. Install equipment giving right of way to piping installed at required slope.
- F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.
- G. Do not install equipment or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

- A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.
- B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

- C. Concrete housekeeping pads and foundations shall be not less than 4 inches high and shall extend a minimum of 6 inches beyond equipment bases. Provide wire-mesh reinforcement; chamfer exposed edges and corners; and finish exposed surfaces smooth.

3.3. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

- A. General: Record demonstration and training video recordings. Record each training module separately.
 - 1. At beginning of each training module, record each chart containing learning objective and lesson outline.
- B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer
- C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.
- D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.
- E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.4. PROVISIONS FOR ACCESS

- A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, dampers, filters, controls, control devices, cleanouts, traps, and other devices requiring maintenance, service, adjustment, balancing or manual operation.
- B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 24 inches x 24 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manu-factured by Inland-Ryerson, Mifab, or approved equal.
 - 1. Acoustical or Cement Plaster: Style B
 - 2. Hard Finish Plaster: Style K or L
 - 3. Masonry or Dry Wall: Style M
- C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.
- D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade

for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish.

- E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.
- F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, and similar spaces, etc.) provide aluminum access doors/frame.

3.5. PAINTING AND FINISHES

- A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.
- B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.
- C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.
- D. Protect all finishes and restore any finishes damaged as a result of work under Division 22 to their original condition.
- E. The preceding requirements apply to all work, whether exposed or concealed.
- F. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.
- G. All exposed piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.
- H. All exterior roof mounted equipment, piping and vents shall be painted to match roof in color as selected by Architect.
- I. All exposed piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.
- J. All exposed piping, equipment, etc., in Mechanical Rooms, Penthouses, Fire Pump Rooms, Mezzanines, and Storage where PVC jacketed shall not require painting. Label and identify and color code as specified.

3.6. CLEANING OF SYSTEMS

- A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.
- B. Flush piping in re-circulating water systems to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after

cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating name of Service Company used.

- C. Maintain strainers and dirt pockets in clean condition.
- D. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.
- E. Leave systems clean, and in complete running order.

3.7. COLOR SELECTION

- A. Color of finishes shall be as selected by the Architect.
- B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.8. PROTECTION OF WORK

- A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.
- B. Cover temporary openings in piping and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.
- C. Cover or otherwise protect all finishes.
- D. Replace damaged materials, devices, finishes and equipment.
- E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

3.9. OPERATION OF EQUIPMENT

- A. Clean all systems and equipment prior to initial operation for testing, balancing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.
- B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.
- C. Submit factory start-up sheets or field start-ups sheets for all equipment prior to the commencement of testing and balancing work. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

- D. Do not use plumbing systems for temporary services or temporary conditioning during construction. Refer to Division 01 section "Temporary Facilities and Controls" for temporary plumbing during construction.
- E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

- A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.
- B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as "Normally Open" or "Normally Closed" as required.
- C. All items of equipment, including motor starters and disconnects shall be furnished with white on black plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal). Equipment identification and room name or area served shall be on each panel.
- D. Provide six (6) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Operations and Maintenance Manuals as hereinafter specified.
- E. All lines piping installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and service. Refer to Division 22 Section, Plumbing Piping, Fittings, Valves, Etc. Color code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.
- F. Submit list of wording, symbols, letter size, and color coding for plumbing identification. Submit samples of equipment identification cards, piping labels, labels, and valve tags to Engineer for review prior to installation.
- G. Provide at least eight (8) hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner. Additional instruction time for the automatic temperature control (ATC) system is specified in Division 23 Section, Instrumentation and Controls of HVAC and Plumbing Systems.
- H. Contractor shall demonstrate Sequences of Operation of all plumbing equipment in presence of Owner's representative, Engineer, and ATC subcontractor.

3.11. WALL AND FLOOR PENETRATION

- A. All penetrations of partitions, ceilings, roofs and floors by piping or conduit under Division

22 shall be sleeved, sealed, and caulked airtight for sound and air transfer control. Penetrations of mechanical room partitions, ceilings, and floors shall be as specified in Division 07 Section, "Fire Protection, HVAC and Plumbing Penetration Firestopping".

- B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC and Plumbing Penetration Firestopping".
- C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.
- D. Provide pipe escutcheons and duct flanges for sleeved pipes and ducts in finished areas.
- E. Piping sleeves:
 - 1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.
 - 2. Twenty-two (22) gauge galvanized steel elsewhere.
- F. Extend all floor sleeves through floor at least 2-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.

3.12. RECORD DRAWINGS

- A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the mechanical contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.
- B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

- A. Contractor's attention is directed to warranty obligations contained in the General Conditions and Supplementary Conditions.
- B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer's warranties shall be included in the operations and maintenance manuals.
- C. The contractor guarantees for a two year period from the time of final acceptance by the Owner.
 - 1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.
 - 2. That all work, equipment, machines, devices, etc. shall be adequate for the use to

which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.

3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section.
4. That the entire work shall be water-tight and leak-proof.

3.14. OPERATIONS AND MAINTENANCE MANUALS

- A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operations and Maintenance Manuals and deliver these copies of the manuals to the Owner. The manuals shall be as specified herein. The manuals must be approved and will not be accepted as final until so stamped.
- B. The manuals shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manual Cape Henlopen High School Expansion – Plumbing Systems. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.
- C. Provide the following data in the booklet:
 1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.
 2. Catalog data on each piece of plumbing equipment furnished.
 3. Maintenance operation and lubrication instructions on each piece of plumbing equipment furnished.
 4. Complete catalog data on each piece of plumbing equipment furnished including approved shop drawing.
 5. Manufacturer's extended limited warranties on equipment.
 6. Chart form indicating frequency and type of routine maintenance for all plumbing equipment. The chart shall also indicate model number of equipment, location and service.
 7. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.
 8. Provide supplier and subcontractor's names, address, and phone number.
 9. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.
 10. Provide and install in locations as directed by the Owner, valve charts including

valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass. .

11. Copy of the approved balancing report for plumbing equipment/system.
 12. Access panel charts with index illustrating the location and purpose of access panels.
 13. Approved Health and Plumbing and Electrical Certificates.
 14. Start-up reports for equipment.
 15. Insert color graphic with embedded parameters for ATC system into Record and Information Booklet.
- D. Submit Operations and Maintenance Manuals prior to the anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Operations and Maintenance Manuals reviewed and approved.

3.15. INSTALLATION AND COORDINATION DRAWINGS

- A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following:
1. Complete Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.
- B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment, and piping in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.
- C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.

3.16. PIPING SYSTEMS TESTING

- A. The entire new plumbing piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of four (4) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	TEST PRESSURE
Domestic Water & Coil Drain Piping	100 psi
Sanitary & Storm Water Piping	As specified below

SYSTEM	TEST PRESSURE
Emergency Fixtures, Tempered Water	100 psig

- B. All gas piping shall be pressure tested in accordance with NFPA-54. Gas piping systems shall be proven tight under the following gauge pressures for a duration of four (4) hours:

SYSTEM	TEST PRESSURE
Gas Piping	100 psig

- C. All storm, waste, vent and water piping shall be tested by the Contractor and approved by the Engineer before acceptance. All storm, soil, and waste piping, located underground, shall be tested before backfilling. The costs of all equipment required for tests are to be included in the contract price.
- D. The entire new drainage system and venting system shall have all necessary openings plugged and filled with water to the level of the highest stack above or at the roof. The system shall hold this water for thirty (30) minutes without showing a drop greater than 1 inch. Where a portion of the system is to be tested, the test shall be conducted in the same manner as described for the entire system, except a vertical stack 10 feet above the highest horizontal line to be tested may be installed and filled with water to maintain sufficient pressure, or a pump may be used to supply the required pressure. The pressure shall be maintained for thirty (30) minutes. All testing shall be in accordance with the local Plumbing Code and witnessed by the Plumbing Inspector or authority having jurisdiction.
- E. Upon completion of roughing-in and before setting equipment and fixtures, the entire new water piping system shall be tested at a hydrostatic pressure of not less than one hundred (100) pounds per square inch gauge and proven tight at this pressure. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately in a manner described for the entire system.
- F. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

3.17. EQUIPMENT BY OTHERS

- A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions or furnished by the Owner. Connections shall be complete in all respects to render this equipment functional to its fullest intent.
- B. It shall be the responsibility of the supplier of this equipment to furnish complete instructions for connections. Failure to do so will not relieve this contractor of any responsibility for improper equipment operation.

3.18. OUTAGES

- A. Provide a minimum of fourteen (14) days' notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.
- B. Submit Outage Request form, attached at end of this Section, to Owner for approval.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: _____ BY: _____

DATE FOR OUTAGE: _____ FIRM: _____

START OUTAGE-TIME: _____ DATE: _____

END OUTAGE -- TIME: _____ DATE: _____

AREAS AND ROOMS: _____

FLOOR(S): _____

AREA(S): _____

ROOM(S): _____

WORK TO BE PERFORMED: _____

SYSTEM(S): _____

REQUEST APPROVED BY: _____

(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: _____

YES ____ NO ____ BY: _____ DATE: _____

DATE/TIME-AS REQUESTED: _____ OTHER : _____

OWNER'S PRESENCE REQUIRED: _____

YES: ____ NO: ____ NAME: _____

DIVISION 22 SECTION 220505
PLUMBING PIPING, FITTINGS & VALVES
TABLE OF CONTENTS

PART 1. GENERAL.....	3
1.1. SUMMARY.....	3
1.2. SYSTEM DESCRIPTION CONDITIONS.....	3
1.3. QUALITY ASSURANCE.....	3
1.4. DELIVERY, STORAGE AND HANDLING.....	4
1.5. ENVIRONMENTAL REQUIREMENTS.....	4
1.6. EXTRA MATERIALS.....	4
1.7. ALTERNATES.....	4
1.8. LEAD FREE REQUIREMENTS.....	4
1.9. PLASTIC PIPE PENETRATIONS.....	4
PART 2. PRODUCTS.....	4
2.1. PIPE MATERIALS.....	4
2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES.....	8
2.3. VALVES.....	11
2.4. BACKWATER VALVE:.....	11
2.5. STRAINERS.....	11
2.6. UNIONS, FLANGES, AND COUPLINGS.....	12
2.7. MANUAL AIR VENTS.....	12
2.8. THERMOMETERS.....	12
2.9. PRESSURE GAUGES.....	13
2.10. PIPING SPECIALTIES.....	13
2.11. ESCUTCHEONS.....	14
2.12. DIELECTRIC CONNECTIONS:.....	14
2.13. SLEEVES.....	14
2.14. PRESSURE REDUCING VALVES.....	15
2.15. WATER PROOF PIPE PENETRATION SEALS.....	15
2.16. GAS PRESSURE REGULATORS.....	15
2.17. TRANSITION FITTINGS.....	15
PART 3. EXECUTION.....	16
3.1. GENERAL PIPING INSTALLATION REQUIREMENTS.....	16
3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.....	18
3.3. VALVE INSTALLATION REQUIREMENTS.....	18
3.4. WASTE AND VENT PIPING INSTALLATION REQUIREMENTS.....	19
3.5. PIPE JOINTS INSTALLATION REQUIREMENTS.....	20
3.6. HANGERS AND SUPPORTS INSTALLATION REQUIREMENTS.....	22
3.7. AIR VENTING INSTALLATION REQUIREMENTS.....	23
3.8. DIRT POCKETS INSTALLATION.....	23
3.9. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS.....	23
3.10. PIPING IDENTIFICATION REQUIREMENTS.....	23
3.11. VALVE IDENTIFICATION REQUIREMENTS.....	24
3.12. CLEANING PIPING AND EQUIPMENT.....	24
3.13. BACKWATER VALVE INSTALLATION REQUIREMENTS.....	25
3.14. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS.....	25

END OF SECTION 25

SECTION 22 05 05**PLUMBING PIPING, FITTINGS AND VALVES****PART 1. GENERAL****1.1. SUMMARY**

- A. The conditions of the contract and other general requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 22 Section, Common Work Results for Plumbing and Division 01, General Requirements.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SYSTEM DESCRIPTION CONDITIONS

- A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings. Final connections to equipment furnished in other sections of the specifications shall be included under this section.
- B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and International Building Code (IBC).
- C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.
- F. Provide pipe hangers and supports in accordance with ASTM B31.9 and MSS SP69 unless indicated otherwise.
- G. Use spring loaded "silent" check valves on discharge of all pumps.
- H. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.
- I. At all runout piping serving equipment, use swing joints with elbows to prevent excessive movement of piping due to expansion.

1.3. QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.

- B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
- C. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.
- D. Maintain one copy of each document on site.

1.4. DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to site under as hereinbefore specified.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

- A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

- A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

1.8. LEAD FREE REQUIREMENTS

- A. All plumbing fixtures, equipment, and devices that contact potable water must be lead free per the State requirements.

1.9. PLASTIC PIPE PENETRATIONS

- A. Install UL listed collars, sealing methods, and firestopping at all plastic pipe penetrations of smoke walls and fire rated walls per NFPA.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

- A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and

insurance authorities having jurisdiction.

1. Sanitary Underground - Within Building to 5 Feet Outside of Foundation Wall:
 - a. PVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
2. Sanitary and Vents Above Floor Inside Building:
 - a. PVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
3. Indirect Waste Piping:
 - a. Pipe & Fittings: Hard drawn Type L copper tubing with cast brass drainage fittings. ASTM B88-78 and ANSI B16.1877. All exposed indirect waste piping shall be chrome plated or primed and painted with silver paint.
4. Storm Water Below Grade or Under Building to Point 5 Feet from Building Line:
 - a. PVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
5. Storm Water Above Floor Inside Building:
 - a. PVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.
6. Domestic Hot, Cold, and Recirculating, Water Piping Inside Buildings, Above Grade:
 - a. Pipe or Tubing: 2 inches & smaller, all water lines soft temper Type K copper tubing below ground, hard temper Type L copper tubing above ground, ASTM B88, or Type 304/304L, Schedule 10S, stainless steel to ASTM A312.
2-1/2 inches & larger, hot dipped galvanized steel A120, ASTM A53, Grade B, Schedule 40 steel, or hard copper tube, Type L with copper-tube dimensioned grooved ends; copper ground - end fittings; copper tubing, keyed couplings; and grooved joints. (Flaring of tube or fitting ends to accommodate alternate sized couplings is not permitted.)
Provide dielectric fittings between steel and copper. Victaulic Style 47 or approved equal.
 - b. Fittings & Joints: Copper tubing fittings and joints shall be solder type wrought copper - 95-5 silver solder or braze (lead and antimony based solders are prohibited). Galvanized steel pipe fittings and joints shall be ANSI B16.12 hot dipped galvanized threaded ends and 125 lb. galvanized

cast iron fittings or 150 lb. galvanized malleable iron.

- i. Stainless steel fittings shall be Vic-Press or approved equal for Schedule 10S pipe. Fittings shall be precision, cold drawn, stainless steel with EPDM O-ring seals. (Seals shall be UL classified in accordance with ANSI/NSF61 for Potable Water service.) Fittings rated for working pressures to 500-psi.
- ii. Grooved joint couplings shall consist of two ductile iron housing segments cast with offsetting angle pattern bolt pads, FlushSeal elastomer gasket, and ASTM A449 electroplated steel bolts and nuts. (Gasket shall be UL classified in accordance with ANSI/NSF61 for Potable Water service, and shall meet the lead content requirements of NSF-372.) Installation-Ready, for direct stab installation without field disassembly. Victaulic Style 607H or approved equal.
- iii. Installation-ReadyTM fittings for grooved end copper tubing shall be manufactured to copper-tube dimensions. Fittings shall be ductile iron conforming to ASTM A-536, Grade 65-45-12, with Installation-ReadyTM ends, complete with PVDF (Poly Vinylidene Fluoride) and Grade "EHP" EPDM-HP (Grade 'T' Nitrile) gasket; and ASTM A449 electroplated steel bolts and nuts. System shall be rated to 300 psi (2065 kPa) with Type K or L Copper Tubing.
 - 1) UL classified in accordance with NSF-61 for potable water service. The system shall meet the low-lead requirements of NSF-372.
- c. Gate Valves: 2-1/2 inches & larger - OS&Y, IBBM flanged, 125 lb. standard solid wedge.
 - i. 2 inches & smaller - bronze solder end, bronze body, solid wedge, rising stem, 200 lb. w.o.g. non-shock. However, use brass valves only on all copper pipe.
- d. Butterfly Valves: Cast brass body to UNS C87850, elastomer pressure responsive seat, aluminum-bronze disc with stainless steel stem. Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating. Copper-tube dimensioned grooved ends, suitable for working pressures to 300-psig CWP Victaulic Style 608N or approved equal.
- e. Ball Valves: Shut-off valves 2-inches and smaller shall be ball valves. Ball valves shall be 150 lbs, brass or bronze body, standard port, 2 piece body, TFE seats with bronze trim. Ball valves shall be threaded end or solder end, or Vic-Press end as required to accommodate piping. Ball valves shall be as manufactured by Victaulic, Conbraco, Crane, Apollo, Nibco, Watts or engineer approved equal.
- f. Unions: 2-1/2 inches & larger - 150 lb. brass companion flanges.
 - i. 2 inches & smaller - wrought copper, ground joint solder ends; threaded hexagonal stainless steel union with Vic-Press ends, Victaulic P589 or approved equal.
- g. Check Valves: 2-1/2 inches & larger - IBBM, 125 lb. std. flanged bronze swing check, with metal disc; 2-inches and smaller - 125 lb. std. screwed or solder ends.
- h. Globe Valves: 2 inches and smaller, bronze body, bronze trim, rising stem, hand wheel, inside screw, renewable composition disc, solder ends,

- 150 lb, with back seating capacity.
- i. 2 inches & larger: IBBM, 150 lb, bronze trim, rising stem, handwheel OS&Y, plug type disc, flanged ends, renewable seat and disc.
 - ii. Globe valves shall be Conbraco, Crane, Nibco, Milwaukee, Watts or approved equal.
 - i. Combination Shut-off/Balancing Valves:
 - i. Victaulic/TA Hydronics, Taco Circuit Setter, Bell & Gossett Circuit Setter Plus, Flowset Accuset, Gerand, or engineer approved equal, ½ inch-3 inches 300 psi rated globe type or ball valve with DZR brass Ametal (copper-alloy) or bronze body/brass ball construction with glass and carbon filled TFE seats, in-line flow meter and balancing and shut-off valve with built in ball valve for flow adjustment. Valve shall have memory stop, calibrated nameplate, Schrader valve connections and preformed molded insulation. Valves shall be leaktight at full rated working pressure. Balance valve size shall be selected based on manufacturer's acceptable flow range and design flow rate. Pressure drop through combination shut off balance valves shall not exceed 5 feet of head at design flow rate.
 - j. Extended Valve Stems: Provide and install round collar type extended valve stems on all valves installed in insulated piping. Valve stem and collar shall be selected to suit insulation thickness and maintain valve handles outside of insulation.
 - k. (Alternate): At contractor's option, Viega ProPress pressure seal mechanical fittings may be utilized.
 - i. Viega, ProPress Pressure Seal Fittings: Bronze, or copper shall conform to ASME B16.51, ICC LC 1002, IAPMO PS 117, NSF 61, and NSF 61-G or NSF 372. ProPress fittings ½-inch thru 4-inch for use with ASTM B88 copper tube type L and ½-inch up to 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element grip ring, PBT separator ring, EPDM sealing element and Smart Connect (SC) feature.

7. Gas Piping:

- a. Pipe: Inside Building Above Ground: Schedule 40 uncoated black steel pipe, ASTM A53 or A120.
- b. Outside Building, Below Ground: Copper type L tubing, ASTM B88 Below Ground.
- c. Outside building above grade/roof: Schedule 40 black steel pipe, ASTM A53 or A120.
- d. Fittings & Joints: 150 lb. screwed malleable iron ASTM B16.3 with joints sealed with litharge and glycerin. Piping 2 ½ inches and larger and any concealed piping within walls must be welded, ASTM A24 forged steel welded type joints shall be threaded or welded to ANSI B31.1 or ASME Sec. 1.
- e. Plug Valves: 2- ½ inches & larger ASME B16.38 and MSS SP-78 cast iron lubricated plug valves with 125 psig pressure rating, 3 turn type. Gas valves are prohibited above ceilings.
- f. Cocks: 2 inches & smaller - bronze, Crane 270. AGA certified bronze

body, plug type with bronze plug, ball type with chrome plated brass ball, for 5 psig or less gas. Include AGA stamp, flat or square head or lever handle, and threaded ends conforming to ASME B1.20.1

- g. Ball Valves: Full flow, double seal, ball type with bronze body, Buna-N seals and O-ring packing, chrome plated brass ball and designed for working pressures up to 175 psig. Valves shall be 3 turn type. MSS SP-78, class 175 WOG.
- h. Gas Vents: Install vent piping for gas pressure regulators and gas trains, extend outside building to a non-hazardous location away from any potential source of ignition, and vent to atmosphere. Pipe material shall be identical to gas piping here-in before specified. Terminate vents with turned down, reducing elbow fittings with corrosion-resistant insect screen in large end.
- i. Finish: All gas piping downstream of regulator, installed exposed or piping installed on a roof shall be primed and finished with two coats of rust resistant paint with pewter gray finish. Paint shall be two part epoxy-exterior paint as manufactured by Pittsburgh Paint, Themeco, or approved equal. Painting shall be provided under another Section of these Specifications.

8. Sump Pump Discharge Piping:

- a. Piping: Schedule 40 A53 grade A galvanized steel pipe with cast iron plain galvanized pressure fittings.
- b. Fittings and Joints: Galvanized ductile iron grooved end fittings or malleable iron fittings conforming to ANSI B16.3 Class 150 threaded. 3 inch and larger shall be flanged cast iron.
- c. Basis of Design: Victaulic Series 318 Sump Ejector

- B. Steel pipe shall be similar and equal to National Tube Company, Grinnell, Republic, or Bethlehem black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.
- C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.
- D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES

- A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260, Carpenter and Patterson, or approved equal for pipe 3/4-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not

be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - 1/2	6	8	3/8
2	8	8	3/8
2 - 1/2	10	9	1/2
3	12	10	1/2
4	14	12	5/8
5	14	12	5/8
6	16	14	3/4
8	18	16	7/8
10	20	18	7/8

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
12	20	18	7/8

- B. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters.
- C. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1 ½ and NPS 2 (DN and DN 50): 48 inches (1200 mm) with 3/8 inch (10-mm) rod.
 2. NPS 3 (DN 80): 48 inches (1200 mm) with ½ inch (13 mm) rod.
 3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8 inch (16 mm) rod.
 4. NPS 6 (DN 150): 48 inches (1200 mm) with ¾ inch (19 mm) rod.
 5. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1200 mm) with 7/8 inch (22 mm) rod
- D. Install supports for vertical PVC piping every 48 inches (1200 mm).
- E. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.
- F. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
- G. Hangers for cold pipe sizes 2 inches (50 mm) and over: Carbon steel, adjustable, clevis.
- H. Hangers for cold pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.

- I. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.
- J. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook
- K. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp.
- L. Vertical Support: Steel riser clamp.
- M. Floor support for cold pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- N. Floor support for hot pipe sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- O. Copper pipe support: Carbon steel ring, adjustable, copper plated.
- P. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
- Q. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.3. VALVES

- A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer.
- B. Check valves in base mounted pump discharges shall be of the vertical type and shall be Miller "non-slam" check valves or approved equal suitable for service intended. Check valves in circulator discharges shall be horizontal type.

2.4. BACKWATER VALVE:

- A. Provide backwater valves for all floor drains and foundation drains connecting directly to the storm water system and where indicated on drawings. Backwater valves shall be constructed of coated cast-iron body, hub inlet and offset spigot outlet, bronze bolted cover, automatic type valve seat and flapper which remains closed during periods of non-operation. Provide RectorSeal Clean Check extendable backwater valves for underslab/below-grade condensate lines as indicated on drawings.
- B. Extend access cover to finished floor and terminate in an adjustable floor cleanout as specified hereinbefore.
 - 1. Josam Back Water Valve
 - 2. Zurn Series No. Z1095-FC
 - 3. Jay R. Smith Series No. Fig. 7012

2.5. STRAINERS

- A. Strainers shall be of the basket or "Y" type and shall be heavy and durable, constructed of best grade gray iron with the bottoms drilled and plugged. Bodies shall have arrows clearly cast on the sides to show flow direction. Strainers shall be equipped with easily removable covers and brass sediment baskets made of brass not less than #22 gauge in thickness. Total area of basket perforations shall be not less than four times the cross section of the entering pipe. Flow shall be into basket, and then out through the perforations. Strainers shall be suitable for water or the intended fluid. Strainers 2 inches and smaller shall have threaded or solder ends, 2 inches and larger shall have flanged ends.
- B. Strainer screens shall be stainless steel with perforations and shall be 1/16-inch for pipe sizes 5 inches and less, 1/8-inch (40 percent open area) perforations for pipe sizes 6-inch and greater.
- C. Provide valved and capped (with chain) blowdowns in each strainer. Blowdown valves shall be Appolo 78-100/200 series or as approved equal.
- D. Strainers shall be manufactured by Watts, Mueller, Armstrong, Yarway, Spirax/Sarco or as approved equal.

2.6. UNIONS, FLANGES, AND COUPLINGS

- A. Unions in steel pipe 2-inches and smaller shall be malleable iron with brass inserted seats designed for a working pressure of 150 psig.
- B. Unions in copper pipe 2-inches and smaller shall be sweat fittings with bronze seats designed for a working pressure of 125 psig.
- C. Flanges for steel pipe over 2 inches shall be 150 psig, forged steel, slip on. Gaskets shall be 1/16 inch thick pre-formed neoprene.
- D. Flanges for copper pipe over 2 inches shall be bronze. Gaskets shall be 1/16 inch thick preformed neoprene.

2.7. MANUAL AIR VENTS

- A. Manual air vents shall be similar to the hereinafter specified gauge valves. Provide 1/4-inch size on 3/4-inch pipe and smaller, 1/2 -inch size on 1-inch pipe and larger. Install at all high points of piping. Valves shall be Crane No. 88, or as approved equal, with threaded ends, bronze body, bronze or brass bonnet and bronze stem.

2.8. THERMOMETERS

- A. Unless otherwise indicated, thermometers shall be ASTM E1, in a glass type, organic filled, 9-inch scale size, corrosion-resistant metal case, with "any-angle" mounting with positive locking device. Terrice Industrial Thermometers, Weksler Instruments, Ernst Gage Co., Miljoco, or approved equal. Insertion stem length shall suite the pipe size and configuration. Thermometer wells shall be brass with brass union hubs in copper and in ferrous piping. Where piping is insulated or otherwise covered, use wells with lagging extension. Where wells are installed in pipe tees at turns, increase pipe size so that well does not restrict flow. Accuracy shall be 2 percent.

- B. Unless otherwise indicated, thermometer ranges shall be as follows:
 - 1. Domestic cold water: 0 degrees F to 100 degrees F, 1 degrees F Division.
 - 2. Domestic hot and hot water recirculating: 30 degrees F to 180 degrees F, 2 degrees F Division.
- C. Provide heat conducting compound in wells.

2.9. PRESSURE GAUGES

- A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.
- B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.
- C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.
- D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.
- E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.10. PIPING SPECIALTIES

- A. Furnish and install flexible pipe connections, as specified and/or shown on the drawings, at suction and discharge connections of all in-line pumps, all vibrating equipment and elsewhere as shown. Refer to Division 23 Section, Vibration Control for HVAC, Plumbing and Fire Protection Equipment for specifications.
- B. Pressure relief valves shall be provided in the number and sizes required to relieve 110 percent of the full input to the systems. Valves shall be rated; and installed in accordance with ASME, and CSD-1 including all amendments. Pipe discharge full size to floor drain, (with union) and support discharge pipe to prevent exerting any strain on relief valve body, piping to be Type-L copper. Water safety relief valves shall be Watts Series 740, Conbraco, Series 154A, Bell and Gossett, or approved equal. Provide pressure gauge adjacent to all safety relief valves.
- C. Gas relief valve piping shall be sized and installed in accordance with the latest edition of ASME Boiler & Pressure Vessel Code, CSD-1 including amendments. Pipe material shall be as specified for gas piping. Gas relief valve piping material shall be the same as

hereinbefore specified for gas piping.

2.11. ESCUTCHEONS

- A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.
- B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.12. DIELECTRIC CONNECTIONS:

- A. Furnish and install electrically insulated dielectric unions, waterway fittings, or flanges, as manufactured by Victaulic Company, EPCO Sales, Inc., at the following locations:
 - 1. Where steel piping systems join copper piping.
 - 2. Where copper tube connects to domestic water storage tanks, water heaters, heat exchangers, expansion tanks, and other steel vessels.
 - 3. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.
 - 4. Dielectric Waterway: Copper silicon casting conforming to UNS C87850 with grooved and/or threaded ends. UL classified in accordance with NSF-61 for potable water service, and shall meet the low lead requirements of NSF-372. Basis of Design: Victaulic Series 647.

2.13. SLEEVES

- A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.
- B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend $\frac{3}{4}$ -inch above the floor. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for mechanical equipment room penetrations additional requirements. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.
- C. Sleeves through walls and floors shall be sealed with a waterproof caulking compound.
- D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.14. PRESSURE REDUCING VALVES

- A. Provide pressure reducing valves as indicated, of size and capacity selected by the installer to maintain operating pressure on the system. Body shall be cast-iron or bronze construction, renewable stainless steel seat, non-corrosive disc, water tight cage assembly, adjustable pressure ranges and inlet strainer Watts Regulator Model 223-S, Armstrong, Bell and Gossett or as approved equal.
- B. Provide pressure gauge adjacent to all pressure reducing valves to verify proper set point.

2.15. WATER PROOF PIPE PENETRATION SEALS

- A. Provide and install waterproof pipe penetration seals at all pipes that enter the building below grade or through exterior wall.
- B. Link seals are to be Metraflex Metraseals, Model MS, Linkseal, or approved equal, black EPDM seal material, glass reinforced plastic pressure plates, zinc plated nuts and bolts, seals are to be resistant to sunlight and ozone, pressure rated to make a hydrostatic seal of up to 20 psig and up to 40 feet of head, temperature rated from -40 degrees F to 250 degrees F.

2.16. GAS PRESSURE REGULATORS

- A. Gas pressure regulators shall be as manufactured by Equimeter, Inc., Maxitrol Co., Rockwell, Fisher Controls, American Meter Co., or approved equal. Gas pressure regulators shall maintain a constant downstream pressure with a variable inlet pressure.
- B. Gas pressure regulators shall comply with ANSI Z21.18 and shall be single stage, steel jacketed, corrosion-resistant type. Include atmospheric vent, elevation compensator, with threaded ends conforming to ASME B1.20.1 for 2 inch NPS and smaller and flanged ends for 2 ½ inch NPS and larger.
- C. Each pressure regulator shall have an identification stamped on diaphragm cover and shall be painted AGA grey. Regulator inlet and outlet pressures, and flow volume in cubic feet per hour of specified gas are as indicated on the contract drawings.
- D. Regulators installed exposed on roof or outside shall be designed and listed for outside installation.

2.17. TRANSITION FITTINGS

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Charlotte Pipe and Foundry Company.
 - b. Harvel Plastics, Inc.
 - c. Spears Manufacturing Company.
2. Description: PVC or CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket end.

D. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Colonial Engineering, Inc.
 - b. NIBCO INC.
 - c. Spears Manufacturing Company.
2. Description: PVC or CPVC four-part union. Include brass threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

- A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, coils, etc., and installed so that there will be no interference with the installation of the equipment, ducts, etc. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.
- B. All piping shall be graded to convey entrained air to high points where automatic air vents shall be provided. The size of supply and return pipes for each piece of equipment shall in no case be smaller than the outlets in the equipment.

- C. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.
- D. All valves, strainers, caps, and other fittings shall be readily accessible.
- E. Rough-in and final connections are required to all equipment and fixtures provided under this Contract.
- F. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.
- G. Discharge lines from all relief valves shall be piped to within 4-inches of floor and extend to floor drains wherever floors are not pitched to drains. Pitch the relief valve piping away from the relief valve to insure that no fluid can be trapped in valve discharge. Support all relief valve piping to prevent exerting strain on the relief valve body. The end of the relief valve discharge piping shall not be threaded to prevent capping or plugging.
- H. All branches from water mains shall be taken from the top of the supply mains at an angle of forty-five (45) degrees above the horizontal, unless otherwise directed. Branches feeding down shall be taken from the side or bottom of the main on water mains only. All connections shall be carefully made to insure unrestricted circulation, eliminate air pockets or trapped condensate, and permit the complete drainage of the system.
- I. Cutoff valves shall be provided on each branch line from the mains on all plumbing lines.
- J. Shut-off valves shall be installed at the inlet and outlet of each piece of equipment to permit isolation for maintenance and repair.
- K. Balancing valves shall be installed in all domestic re-circulating systems and at all pumps, and where indicated on the drawings.
- L. Unions shall be installed on all bypasses, at all connections to equipment, where shown on drawings or where required to facilitate removal of equipment whether shown or not.
- M. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.
- N. If the size of any piping is not clearly evident in the drawings, the Contractor shall request instructions for the Engineer as to the proper sizing. Any changes resulting from the Contractor's failure to request clarification shall be at his expense. Where pipe size discrepancies or conflicts exist in the drawings, the larger pipe size shall govern.
- O. Install all valves with stem upright or horizontal, not inverted.
- P. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.
- Q. Provide clearance for installation of insulation and access to valves and fittings.

- R. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.
- S. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.
- T. Provide manual air vents at top of piping systems.
- U. Where access doors are required, install piping so that valves can be grouped together to minimize the quantity of access doors.
- V. Install manufactured U.L. listed firestop collars at all floor/wall penetrations for all PVC and CPVC pipe penetrations.

3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.

- A. Install thermometers and adjust vertical and tilted positions.
- B. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.
 - 1. Install with socket extending to one-third diameter of pipe.
 - 2. Fill sockets with oil or graphite and secure caps.
- C. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.
- D. Adjust faces of thermometer and gages to proper angle for best visibility.
- E. Clean windows of thermometer and gauges and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

- F. Examine grooved ends for form and cleanliness. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
- G. Do not attempt to repair defective valves; replace with new valves.
- H. Install valves as indicated, according to manufacturer's written instructions.
- I. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.
- J. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.
- K. Locate valves for easy access and provide separate support where necessary.
- L. Install valves in horizontal piping with stem at or above the center of the pipe.
- M. Install valves in a position to allow full stem movement.
- N. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

3.4. WASTE AND VENT PIPING INSTALLATION REQUIREMENTS

- A. Each pipe shall be laid true to line and grade and in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets of the flow line. All pipe when laid shall rest on the full length of the barrel and bell holes shall be dug in trench bottoms to make joints. Pipe shall not be adjusted to grade by use of block or wedges. Where rock or old foundations are encountered, trenches shall be excavated 6-inches below grade and crusher run limestone shall be used as a bedding material to support barrel of pipe.
- B. As the work progresses, the interior of the sewer shall be cleared of all dirt and superfluous materials of every description.
- C. Trenches shall be kept free from water until the pipe jointing material has set and pipe shall not be laid when the conditions of the trench or the weather is unsuitable for such work. At all times, when work is not in progress, all open ends of pipe and fittings shall be securely closed to the satisfaction of the Engineer, so that no trench water, earth or other substance will enter the pipe or fittings.
- D. Slip joints will be permitted only in trap seals or on the inlet side of the trap. Unions on the sewer side of the trap shall be ground faced, and shall not be concealed or enclosed. Install bell and spigot pipe with bell end upstream.
- E. Threaded joints shall be American Standard taper screw threads with permacel joint compound applied to the male thread. Connections between threaded pipe and cast iron pipe shall have a ring or half coupling screwed on to form a spigot end on the threaded pipe.
- F. Establish invert elevations, slopes for drainage to 1/8 inch per foot. Maintain gradients.

3.5. PIPE JOINTS INSTALLATION REQUIREMENTS

- A. Grooved Joints: Grooved joint shall be installed in accordance with the manufacturer's written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)
- B. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.
- C. Soldered Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.
 - 1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.
 - 2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.
 - 3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.
 - 4. The correct amount of solder per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.
 - 5. Solder joints shall be made by using a direct flame from a torch.
 - 6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the solder starts to melt to insure an even distribution of the solder.
 - 7. The excess solder shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.
 - 8. Solder joints shall be suitable for working pressure of 100 psig and for working temperature of not less than 250 degrees F. The type of solder and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.
 - 9. Lead and antimony-based solders shall not be used for potable water systems. Brazing and silver solders are acceptable.
- D. Where copper piping joins steel piping, approved bronze adapters shall be used.

- E. Prohibited Connections: No direct weld, soldered, or brazed connections, without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.
- F. When installing gas piping which is to be concealed (i.e., in walls), unions, tube fittings, running threads, right- and left-hand couplings, bushings, and swing joints made by combination of fittings shall not be used. All concealed piping within walls shall be welded.

- 1. Gas Piping

- 2. Final Gas Connections: Unless otherwise specified herein, final connections shall be made with rigid metallic pipe and fittings.

- 3. Pipe Joints:

- a. Pipe joints shall be designed and installed to effectively sustain the longitudinal pull-out forces caused by contraction of the piping or superimposed loads.
- b. Threaded Metallic Joints: Threaded joints in metallic pipe shall have tapered threads evenly cut and shall be made with UL approved graphite joint sealing compound for gas service. After cutting and before threading, pipe shall be reamed and burrs shall be removed. Caulking of threaded joints to stop or prevent leaks shall not be permitted.
- c. Welded Metallic Joints: Beveling, alignment, heat treatment, and inspection of welds shall conform to ASME B31.2. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected adversely. Electrodes that have been wetted or have lost any of their coating shall not be used.
- d. Thermoplastic Joints: Jointing procedures shall conform to AGA 01. Solvent cement or heat of fusion joints shall not be made between different kinds of plastics.
- e. Joining Thermoplastic to Metallic Piping: When compression-type mechanical joints are used, the gasket material in the fittings shall be compatible with the plastic piping and with the gas in the system. An internal tubular rigid stiffener shall be used in conjunction with the fitting, and the stiffener shall be flush with the end of the pipe or tubing and shall extend at least to the outside end of the compression fitting when installed. The stiffener shall be free of rough or sharp edges and shall not be a force fit in the plastic. A split tubular stiffener shall not be used.
- f. Special Requirements; Drips, grading of the lines, freeze protection, and branch outlet locations shall be as shown and shall comply with NFPA 54.
- g. Install containment conduits for gas piping below slabs, within building, in gastight conduits extending minimum of 4 inches (100mm) outside building, and vented to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.
- h. Install gas meter per manufacturer's requirements.

- i. Install metal shut-off valves upstream and downstream of gas meter with full size normally closed bypass valve.
 - j. Install strainer on inlet of gas meter.
- 4. Install concrete filled, steel, schedule 40, painted pipe bollards around gas meter and regulator.
- G. Plastic piping solvent cement joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe handling practice of cleaners, primers, and solvent cements. Apply primer.
 - 2. PVC Piping: Join according to ASTM D2855.

3.6. HANGERS AND SUPPORTS INSTALLATION REQUIREMENTS

- A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Provide protection saddles between hangers and insulation on heating water insulated pipe. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal.
- B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping. For cast iron soil pipe, one hanger shall be placed at each hub or bell.
- C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.
- D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.
- E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.
- F. Select hangers and components for loads imposed. Secure rods with double nuts.
- G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.
- H. Support overhead piping with clevis hangers.

- I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.
- J. Refer to structural documents for appropriate connection/attachment materials to building.

3.7. AIR VENTING INSTALLATION REQUIREMENTS

- A. The top of each plumbing piping system and other points as indicated or where necessary for the removal of air from the system or equipment, shall be vented using an approved type of manual air vent.
- B. In addition to manual air vents at high points of system, each item of water heat transfer equipment shall be manually vented using an approved type manual air vent. All air vents shall be accessible.

3.8. DIRT POCKETS INSTALLATION

- A. Dirt pockets shall be installed at the base of all risers and ahead of all gas equipment and as indicated on the drawings.

3.9. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS

- A. Install expansion fittings according to manufacturer's written instructions.
- B. Install expansion fittings in sizes matching pipe size in which they are installed.
- C. Align expansion fittings to avoid end loading and torsional stress.
- D. Install pipe bends and loops cold sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- E. Attach pipe bends and loops to anchors.
 - 1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.
- F. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- G. Connect risers and branch connections to plumbing equipment with at least four pipe fittings, including tee in riser.
- H. Connect mains and branch connections to plumbing equipment with at least four pipe fittings, including tee in main.

3.10. PIPING IDENTIFICATION REQUIREMENTS

- A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply

with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.

- B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
$\frac{1}{2}$ to $1\frac{1}{4}$	8	$\frac{1}{2}$
$1\frac{1}{2}$ to 2	8	$\frac{3}{4}$
$2\frac{1}{2}$ to 6	12	$1\frac{1}{4}$
8 to 10	24	$2\frac{1}{2}$
Over 10	32	$3\frac{1}{2}$

3.11. VALVE IDENTIFICATION REQUIREMENTS

- A. All valves shall be tagged with a numbered tag.
- B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.
- C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.
- D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in each mechanical equipment room including each air handling unit mechanical equipment room. Additional copies shall be provided in each copy of the O&M manuals.

3.12. CLEANING PIPING AND EQUIPMENT

- A. All water, plumbing piping, and pumped condensate systems shall be cleaned by filling with a solution of one (1) pound of trisodium phosphate to each 50 gallons of water and circulating this solution for a period of six (6) hours during which time the system shall reach operating temperature. The systems shall then be flushed with fresh water and refilled with fresh water purged of all air.
- B. All water, plumbing, and pumped condensate piping system shall be flushed clean with

fresh water. See Division 22 Sections, Plumbing Fixture and Plumbing Equipment for domestic potable water cleaning and sterilization.

3.13. BACKWATER VALVE INSTALLATION REQUIREMENTS

- A. Install backwater valve with access door to allow service and cleaning of ball check valve.
- B. Access door shall be adequate size to allow full clearance to backwater valves. Paint exterior of access door to match existing wall finish.
- C. Backwater valve size shall be as indicated on floor plans.

3.14. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS

- A. Viega, ProPress Pressure Seal bronze, or copper fittings: Sealing element shall be verified for the intended use. Tube ends shall be cut on a right angle (square) to the tube. Tube ends shall be reamed and chamfered, all grease oil or dirt shall be removed from the tube end with a clean rag. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting. Utilizing a Viega Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Installers shall attend a Viega ProPress installation training class.
- B. After ProPress Pressure seal fittings have been installed a “two step test” shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings. Should you identify an un-pressed ensure the tube is fully inserted into the fitting and properly marked, prior to pressing the joint. After appropriate repairs have been made, retest the system per local code, or specification requirements, not to exceed 600 psi with water or 200 psi when using air.

END OF SECTION

DIVISION 22 SECTION 22 07 01
PLUMBING INSULATION
TABLE OF CONTENTS

PART 1. GENERAL.....	1
1.1. REFERENCE	1
1.2. DESCRIPTION	1
1.3. SCOPE.....	1
1.4. STANDARDS	1
1.5. SYSTEM PERFORMANCE	2
1.6. QUALITY ASSURANCE	2
1.7. DELIVERY AND STORAGE OF MATERIALS	2
1.8. ALTERNATES	3
PART 2. PRODUCTS.....	3
2.1. GENERAL.....	3
2.2. PIPE INSULATION MATERIALS	3
2.3. PIPING INSULATION THICKNESSES SCHEDULE	6
2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES.....	6
2.5. ACCESSORY MATERIALS	7
2.6. FIELD-APPLIED JACKET	7
PART 3. EXECUTION.....	8
3.1. WORKMANSHIP	8
3.2. SITE INSPECTION.....	8
3.3. PREPARATION.....	9
3.4. INSTALLATION	9
3.5. FIELD QUALITY ASSURANCE.....	10
3.6. PROTECTION	11
3.7. SAFETY PRECAUTIONS.....	11
3.8. INSULATION COVERING.....	11
END OF SECTION	11

SECTION 22 07 01

PLUMBING INSULATION

PART 1. GENERAL

1.1. REFERENCE

- A. The Conditions of the Contract and other General Requirements apply to the work specified in this Section. All work under this Section shall be subject to the requirements of Division 22 Section, Common Work Results for Plumbing.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section

1.2. DESCRIPTION

- A. All piping and equipment installed under this Contract shall be covered as specified.

1.3. SCOPE

- A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to all piping, equipment, and systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract.

1.4. STANDARDS

- A. Thermal insulation materials shall meet the property requirements of one or more of the following specifications as applicable to the specific product or use:
 - 1. American Society for Testing of Materials Specifications:
 - a. ASTM C 547, "Standard Specification for Mineral Fiber Preformed Pipe Insulation".
 - b. ASTM C 533, "Standard Specification for Calcium Silicate Pipe & Block Insulation".
 - c. ASTM C 55, "Standard Specification for Mineral Fiber Blanket and Felt Insulation".
 - d. ASTM E 96, "Standard Test Methods for Water Vapor Transmission of Materials".
 - e. ASTM C 585, "Recommended Practice for Inner and Outer Diameters of Rigid Pipe Insulation for Nominal Sizes of Pipe and Tubing (NPS System)".
 - f. ASTM C 612, "Standard Specification for Mineral Fiber Block and Board Thermal Insulation".
 - g. ASTM C 1136, "Standard Specification for Barrier Material, Vapor, "Type 1 or 2 (Jacket only)".
 - h. ASHRAE 90.1 "Energy efficient design of new buildings except low-rise residential buildings", latest edition.

- B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers, and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications.

1.5. SYSTEM PERFORMANCE

- A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) (formerly known as TIMA), to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1, (latest edition) and "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), latest edition. However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. As minimum, all insulation thicknesses shall be as hereinafter specified.
- B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirements of any one of the following specifications:
 - 1. American Society for Testing of Materials ASTM E 84
 - 2. Underwriters' Laboratories, Inc. UL 723
 - 3. National Fire Protection Association NFPA 255
- C. Calcium silicate products shall include a visual identification system to permit positive field determination of their asbestos-free characteristics.

1.6. QUALITY ASSURANCE

- A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

1.7. DELIVERY AND STORAGE OF MATERIALS

- A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.
- B. The Contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use all means necessary to protect work and materials installed by other trades.
- C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the Contractor shall not install such material, and shall remove it from the job

site. An exception may be allowed in cases where the Contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer in writing for technical assistance.

- D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Protect all insulation from water, construction traffic, dirt, chemical and mechanical damage.

1.8. ALTERNATES

- A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. GENERAL

- A. All materials to be insulated shall be thoroughly cleaned, after completion of successful tests, and shall be covered as specified below. Fiberglass insulation shall be Owens-Corning, Manville, Armstrong, or P.P.G, or as approved equal.

2.2. PIPE INSULATION MATERIALS

- A. Unless otherwise noted, insulation shall be one piece or half sectional molded fibrous glass with "K" rating of .23 at 75 degrees F mean temperature, for service temperatures between -60 degrees F and +450 degrees F with all service poly-encapsulated jacket. Pipe insulation shall be fiberglass ASJmax SSL II with double closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.
- B. Unless otherwise noted, pipe insulation jacket shall be factory-applied vinyl coated, embossed and reinforced vapor barrier laminate, with a perm rating of not more than 0.02 perms. All hot and cold, concealed and exposed butt strips shall be of the same material as the jacket. Jacket and butt strips shall be sealed with field-applied Foster 85-20/85-50 or Childers CP-82 (5 gallon cans only) adhesive. Jacket and butt strips shall be off-white color and shall be equivalent to Owens-Corning Fiberglass 25-ASJ.
- C. For fittings on all piping, valves, and flanges, apply fiberglass molded or segmented insulation equal in thickness to the adjoining insulation and securely fasten in place using wire. Cold piping: Apply a tack coat of vapor barrier coating and reinforcing mesh. After ½ hour, apply second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping. Hot piping Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of breather mastic over the reinforcing cloth, working it to a smooth finish. As an option to the above hot fittings, a polyvinyl chloride fitting cover may be supplied.
- D. All pipe insulation, jackets, or facings, and adhesives used to adhere jacket or facing to the insulation, including fittings and butt strips, shall have non-combustible fire and smoke hazard system rating and label as tested by ASTM E-84, NFPA 225, and UL 73, not

exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50. Accessories such as adhesives, mastic cements, tapes and cloth for fittings shall have the same ratings as listed above. All products or their shipping cartons shall bear the Underwriter's label indicating that flame and smoke ratings do not exceed the above criteria.

- E. For piping having a vapor barrier insulation and for all insulated piping requiring supports, hangers and supports shall be installed outside the insulation. Wherever hangers and supports are installed outside the insulation, pipe insulation protecting shields shall be provided. Where insulation is a load bearing material, of sufficient strength to support the weight of the piping, pipe shields one-third the circumference of the insulation and of a length not less than three times the diameter of the insulation (maximum length 24-inches) shall be provided. Insulation of 7-1/4 pound or greater density will be considered as load bearing for pipe sizes up to and including 2-inches. Where insulation is not of sufficient strength to support the weight of the piping, a half section of high density fiberglass or foam inserts, shall be provided. Vapor barrier and finish shall be applied as required to match adjoining insulation. In addition, shields shall be furnished as specified above.
- F. For piping located outside of the building, a corrugated aluminum weatherproof jacketing system shall be provided. This system shall be Micro-Lot ML as manufactured by Manville, Polyweld by Pabco Metals Corp., Childers, or as approved equal, and installed per the manufacturer's recommendations. Where outdoor piping is receiving electric heat tape, the insulation shall be oversized so that the heat tape is not compressed tightly to the pipe. Pipe jacketing shall be corrugated (3/16-inch) deep aluminum, .016-inch thickness of H-14 temper with aluminum strapping of .75-inch width and .020 inch thickness with moisture barrier. Aluminum jacketing elbows shall be smooth, .016-inch thickness and 1100 alloy. All jacketing shall have an integrally bonded moisture barrier over the entire surface in contact with the insulation. Longitudinal joints shall be applied so they will shed water and shall be sealed completely and shall be sealed completely with metal jacketing sealant. Sealant shall be Foster 95-44 or Childers CP-76. Circumferential joints shall be closed using preformed butt strips following manufacturer's recommendations for securement. Jacket seams shall be located on the bottom side of the horizontal piping.
- G. All disturbed piping insulation in existing areas shall be re-insulated with insulation type, density, and thickness as specified for new piping. Insulation damaged due to new work and demolition only shall be replaced unless otherwise noted.
- H. On cold systems such as domestic cold water, rainleaders, vapor barrier performance is extremely important. All penetrations and seams of the ASJ and exposed ends of insulation must be sealed with vapor barrier coating. The ASJ must be protected with either a vapor barrier coating or a suitable vapor retarding outer jacket. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeance shall be 0.03 perms or less at 45 mils dry at test by ASTM E96.
- I. Fittings and valves shall be insulated with pre-formed fiberglass fittings, fabricated sections of Fiberglass pipe insulation, Fiberglass pipe and tank insulation, Fiberglass blanket insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. Finish shall be with pre-formed PVC fitting covers or as otherwise specified on contract drawings. Where applicable, Victaulic PVC fitting valve and coupling covers shall be utilized. Victaulic PVC covers shall be installed with matching pipe insulation jacketing material, vinyl tape, solvent weld adhesive and appropriate fasteners.

1. Flanges, couplings and valve bonnets shall be covered with an oversized pipe insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends shall be coated with a suitable weather or vapor-resistant mastic as dictated by the system location and service. Finish valve installation with a Tyvac jacket with ends that secure to adjacent piping.
 2. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.
 3. On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems must be sealed with caulking which allows free movement of the stem but provides a seal against moisture incursion. All gauge and thermometer penetrations and extensions shall be correctly sealed and insulated to prevent surface condensation.
- J. All piping shall be supported in such a manner that neither the insulation or the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing must be such that the circumferential joint may be made outside the hanger. On cold systems, vapor barrier must be continuous, including material covered by the hanger saddle.
1. Piping systems 3-inches (7.5cm) in diameter or less, insulated with Fiberglass insulation, may be supported by placing saddles of the proper length and spacing, as designated in Owens-Corning Pub. 1-IN-12534, under the insulation. Hangers saddles shall be minimum 16 gauge with a saddle arc of 120 degrees minimum.
 2. For hot or cold piping systems larger than 3-inches (7.5 cm) in diameter, operating at temperatures less than +200 degrees F (93 degrees C) and insulated with fiber glass, high density inserts such as foam with sufficient compressive strength shall be used to support the weight of the piping system. At temperatures exceeding + 200 degrees F (93 degrees C), Owens-Corning Pink or IIG, Calcium Silicate pipe insulation shall be used for high density inserts.
 3. Owens-Corning Pink Calcium Silicate pipe insulation may be used to support the entire weight of the piping system provided the hanger saddle is designed so the maximum compressive load does not exceed 100 psi (7kg/cm).
 4. Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.
 5. Thermal expansion and contraction of the piping and insulation system shall generally be taken care of by utilizing double layers of insulation and staggering both longitudinal and circumferential joints. Where long runs are encountered, expansion joints may be required where single layers of insulation are being used and should be so noted on the contract drawings.
 6. On vertical runs, insulation support rings shall be used.

2.3. PIPING INSULATION THICKNESSES SCHEDULE

- A. All piping shall be insulated with pipe insulation of the thicknesses indicated below:

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
All Horizontal Roof Drain Piping Including Sumps	1-inch thickness
All Drain Piping from Cooling Coils/Evaporators	½-inch thickness
All Domestic Hot and Cold Water Piping, including Re-circulating Piping	1-inch thickness
All Above Grade Floor Drain Piping Serving AHU Condensate Drains include Drain Sumps and Auxiliary Drain Pipes from Auxiliary Pans	1-inch thickness
Above Grade Trap Priming Lines	½ -inch thickness
Electric Water Cooler Drains	1-inch thickness

2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES

- A. The following equipment shall be insulated with Fiberglass Rigid Board Insulation or Foam Plastic Insulation:
1. Backflow Preventer Valve Bodies.
 2. Plumbing Pumps.
 3. All Pump Volute and Strainers.
- B. Insulation for cold surfaces shall be 1-1/2-inch thickness, 6 lb. density, 705 FRK with a "K" rating of .23 at 75 degrees F mean temperature. Insulation for hot surfaces except as otherwise noted shall be 1-1/2-inch thickness, 6 lb. density, 705 with a "K" rating of .23 at 75 degrees F mean temperature. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be 1-inch by 25 gauge galvanized steel spaced on not over 12-inch centers. All joints and voids shall be filled with Owens-Corning #110 cement, well troweled into openings. For 705 FRK insulation, all joints and voids shall be FRK taped and vapor sealed. There shall be applied over the insulation surface 1-inch galvanized wire netting laced together at all edges and wired to the steel bands with 16 gauge soft annealed wire. Over this shall be applied 2-inch thick layer of Owens-Corning #110 cement applied in two layers. Install metal corner beads at all corners and edges in order to provide a permanent installation. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive at the rate of 60-70 square feet per gallon. Embed into wet coating a layer of 8 ounce canvas smoothed out to avoid wrinkles and lap all seams a minimum of 2-inches. Apply a second brush coat of Sealfas 30-36 or Childers CP-50

AMV1 lagging adhesive to the entire surface at the rate of 60-70 square feet per gallon. Cleanouts, nameplates, and manholes shall not be insulated, and the insulation on surrounding surfaces shall be neatly beveled off at such openings.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum at least 0.040 inch (1.0 mm) thick.
3. For below ambient services, install a vapor barrier coating at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

D. Mechanical fasteners shall be utilized to hold insulation to surface with bands as required to hold the curvature of the material.

E. Support rings shall be provided to support the top head insulation where required.

F. Outdoor installations require a weather barrier mastic for protection of the insulation jacketing.

G. Insulation types materials shall be suitable for temperatures encountered by each item of equipment.

2.5. ACCESSORY MATERIALS

A. Accessory materials installed as part of insulation work under this section shall include, but not be limited to:

1. Closure Materials - Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.
2. Field-applied jacketing materials - sheet metal, plastic, canvas, fiber glass cloth, insulating cement; PVC fitting covers, PVC jacketing.
3. Support Materials - Hanger straps, hanger rods, saddles.
4. Fasteners, weld pins/studs, speed clips, insulation washers.
5. Metal mesh or expanded metal lagging.

B. All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Insulation Standards."

2.6. FIELD-APPLIED JACKET

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto PVC Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 - 2. Adhesive: As recommended by jacket material manufacturer. VOC content not to exceed 250 g/L.
 - 3. Color: High Gloss White
 - 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 - 5. Factory-fabricated tank heads and tank side panels.

PART 3. EXECUTION

3.1. WORKMANSHIP

- A. The Contractor shall take special care to prevent soiling equipment below or adjacent to areas being insulated. He shall be completely responsible for removing insulation cement splashes and smears and all surfaces that he mars or otherwise soils or defaces, and he will be totally responsible for restoring these damaged surfaces to their like-new condition when delivered to the site.

3.2. SITE INSPECTION

- A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.
- B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.
- C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.3. PREPARATION

- A. Ensure that all pipe and equipment surfaces over which insulation is to be installed are clean and dry.
- B. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation.
- C. Ensure that pressure testing of piping systems has been completed prior to installing insulation.

3.4. INSTALLATION

A. Piping Systems

1. General:

- a. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
- b. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.
- c. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tear or other damage. Seal all tears, punctures and other penetrations of the pipe insulation vapor barrier coating.
- d. On exposed piping, locate insulation and cover seams in least visible location.

2. Fittings: Cover valves, fittings, unions, flanges, strainers, flexible connections, expansion joints, pump bodies, strainers, blowdowns, backflow preventers, autoflow valves and similar items in each piping system using one of the following:

- a. Mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs.
- b. Insulation cement equal in thickness to the adjoining insulation.
- c. PVC fitting covers insulated with material equal in thickness and composition to adjoining insulation.

3. Penetrations: Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise specified.

4. Joints:

- a. Butt pipe insulation against hanger inserts. For hot pipes, apply 3-inch (7.5cm) wide vapor barrier tape or bank over butt joints. For cold piping, apply wet coat of vapor barrier lap cement on butt joints, and seal joints

with 3-inch (7.5cm) wide vapor barrier tape or band.

- b. All pipe insulation ends shall be tapered and sealed, regardless of service.

B. Equipment Insulation:

1. General:

- a. Install insulation in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
- b. Install insulation on equipment after installation of heat tracing, painting, testing, and acceptance tests.
- c. Install insulation materials with smooth, even surfaces. Rework poorly fitted joints. Do not use joint sealer or mastic as filler for joint gaps and excessive voids resulting from poor workmanship. Apply insulation using staggered joint method for both single and double layer installation, applying each layer of insulation separately.
- d. Coat insulated surfaces where specified on contract drawings with layer of insulating cement, troweled in a workmanlike manner, leaving a smooth and continuous surface. Fill in seams, broken edges, and depressions. Cover over wire mesh and joints with cement sufficiently thick to remove surface irregularities.
- e. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. Seal all tears, punctures and other penetrations of equipment insulation facing.
- f. Where specification calls for field-applied all-service vapor barrier jacketing, it shall be neatly fitted and tightly secured. Lap seams 2-inches (5cm) (min.). Seal all joints with adhesive. Tape with 3-inches (7.5cm) matching pressure-sensitive tape or 3-inch (7.5cm) glass fabric and vapor barrier coating.
- g. On exposed equipment, locate insulation and cover seams in least visible location.

- 2. **Removable Insulation:** Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance, such as vessel covers, fasteners, flanges, frames accessories, manholes, handholes, cleanouts ASME stamp, and manufacturer nameplates.

- 3. **Areas Left Uninsulated:** Items such as manholes, handholes, clean-outs, ASME stamp, and manufacturers' nameplates should be left uninsulated unless omitting insulation would cause a condensation problem. When such is the case, provide removable insulation and appropriate tagging to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

- 4. **Equipment Exposed to Weather:** Protect outdoor insulation from weather by installation of weather barrier mastic protective finish or jacketing as recommended by the jacketing manufacturer.

3.5. FIELD QUALITY ASSURANCE

- A. Upon completion of all insulation work covered by this specification, visually inspect the

work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

3.6. PROTECTION

- A. Replace damaged insulation which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.
- B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.7. SAFETY PRECAUTIONS

- A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.
- B. The insulation contractor shall conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

3.8. INSULATION COVERING

- A. Unless otherwise noted, all exposed equipment insulation shall have a field applied PVC jacket cover neatly cut and pasted over equipment insulation. PVC shall be high gloss white and shall be 20 mils thick. Exposed areas include, but are not limited to, all mechanical equipment rooms/fan rooms, mezzanines, penthouses, boiler rooms, janitor's closets, kitchens, electric rooms, and piping and ductwork exposed in an occupied space.
- B. Unless otherwise noted, all exposed pipe insulation required to be insulated shall be jacketed with a PVC Jacketing with fitting covers. PVC jacket shall be color fade resistant, white high gloss, U.S.D.A. authorized as manufactured by Proto Corporation or approved equal. PVC jacketing shall be high impact, ultraviolet resistant PVC. Minimum thickness shall be 20 mils, roll stock ready for shop or field cutting and forming.
- C. Where PVC jackets are indicated, install with 1 inch overlap at longitudinal seams and end joints, for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

END OF SECTION

DIVISION 22 SECTION 22 40 00
PLUMBING FIXTURES

TABLE OF CONTENTS

PART 1. GENERAL	1
1.1. GENERAL	1
1.2. REFERENCES	2
1.3. DELIVERY, STORAGE, AND HANDLING	2
1.4. FIELD MEASUREMENTS	2
1.5. EXTRA MATERIALS	2
1.6. GRAB BAR COORDINATION	3
1.7. ALTERNATES	3
PART 2. PRODUCTS	3
2.1. WALL-MOUNTED WATER CLOSETS	3
2.2. WALL-HUNG URINALS	5
2.3. WALL-MOUNTED LAVATORIES	6
2.4. MULTI-STATION LAVATORIES	7
2.5. MOP SINKS	8
2.6. WATER COOLERS – FOUNTAINS	9
2.7. COUNTER SINKS	10
2.8. ICE MAKER OUTLET BOX	12
2.9. THERMOSTATIC MIXING VALVES (INDIVIDUAL FIXTURE TYPE)	12
2.10. PLUMBING FIXTURE SUPPORTS	13
2.11. HANDICAPPED LAVATORY/SINK INSULATION	13
2.12. FIXTURE STOPS/SUPPLIES	13
PART 3. EXECUTION	14
3.1. GENERAL INSTALLATION REQUIREMENTS	14
3.2. PLUMBING SPECIALTY INSTALLATION REQUIREMENTS	15
3.3. FITTINGS FOR FIXTURES SUPPLIED BY OTHERS	16
3.4. TESTING	16
3.5. CLEANING AND STERILIZATION	16
3.6. EXAMINATION	17
3.7. PREPARATION	17
3.8. INTERFACE WITH OTHER PRODUCTS	17
3.9. ADJUSTING	17
3.10. CLEANING	18
3.11. FIXTURE HEIGHTS	18
END OF SECTION	18

SECTION 22 40 00

PLUMBING FIXTURES

PART 1. GENERAL

1.1. GENERAL

- A. For General Mechanical Requirements, see Division 22 Section, Common Work Results for Plumbing & Division 01, General Requirements.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specifications apply to this Section.
- C. All exposed bolts, screws, etc., shall be vandal proof.
- D. All plumbing materials, equipment and fixtures shall be new and of best grade, free of defects and complete with all required appurtenances and accessories.
- E. Piping and insulation are specified under other sections.
- F. Use "Sani-Sett" setting compound for fixtures.
- G. Provide all materials, equipment and perform all labor required to install plumbing system complete as specified, as drawings indicated and as required by the State of Delaware, National Standard Plumbing Code and International Plumbing Code, local code, and all other authorities have jurisdiction. Comply with the current lead free laws per the requirements of the state in which the project is being constructed.
- H. Provide stops for all plumbing fixtures and equipment. Stops are to be accessible.
- I. Provide P traps on fixtures for which traps have not been included as part of furnished equipment. Trap size to equal size of fixture tailpiece.
- J. All exposed metal parts of fixtures shall be chromium plated brass. Piping, fittings, valves, traps and accessories including escutcheons for piping shall be chromium plated where exposed in finished areas.
- K. All faucets for residential kitchen sinks, lavatories, commercial kitchen sinks, drinking fountains, bubblers, and ice makers shall be listed for drinking-water or commercial applications by the National Sanitation Foundation (NSF) or Underwriters Laboratory (U.L.). All required faucets shall comply with NSF Standard 61 for both lead content and leaching rate. Submit documentation indicating compliance for all required faucets.
- L. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:
 - 1. American Gas Association (AGA).
 - 2. National Sanitation Foundation (NSF).
 - 3. American Society of Mechanical Engineers (ASME).
 - 4. National Electrical Manufacturers' Association (NEMA).
 - 5. Underwriters Laboratories (UL).

1.2. REFERENCES

- A. ANSI/ASME A112.6.1 - Supports for Off-the-floor Plumbing Fixtures for Public Use
- B. ASME A112.18.1 - Finished and Rough Brass Plumbing Fixture Fittings.
- C. ANSI/ASME A112.19.1 - Enameled Cast Iron Plumbing Fixtures.
- D. ANSI/ASMI A112.19.2 - Vitreous China Plumbing Fixtures.
- E. ANSI/ASME A112.19.3 - Stainless Steel Plumbing Fixtures (Designed for Residential Use).
- F. ANSI/ASME A112.19.4 - Porcelain Enameled Formed Steel Plumbing Fixtures.
- G. ANSI/ASME A112.19.5 -Trim for Water-Closet Bowl, Tanks, and Urinals (Dimensional Standards).
- H. IAPMO/ANSI Z124.1 - Plastic Bathtub Units.
- I. IAPMO/ANSI Z124.2 - Plastic Shower Receptors and Shower Stalls.
- J. ANSI Z358.1 - Emergency Eyewash and Shower Equipment.
- K. ANSI/ARI 1010 - Drinking-Fountains and Self- Contained, Mechanically-Refrigerated Drinking-Water Coolers.
- L. ANSI/NFPA 70 - National Electrical Code.
- M. IBC - International Building Code

1.3. DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 01, Section General Requirements.
- B. Accept fixtures on site in factory packaging. Inspect for damage.
- C. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.4. FIELD MEASUREMENTS

- A. Verify that field measurements are as indicated on shop drawings and per the manufacturer.
- B. Confirm that millwork is constructed with adequate provisions for the installation of counter top lavatories and sinks.

1.5. EXTRA MATERIALS

- A. Provide two sets of faucet washers and flush valve service kits to the Owner. Provide

correspondence to Engineer that extra materials have been turned over to the Owner.

1.6. GRAB BAR COORDINATION

- A. For handicapped plumbing fixtures coordinate location of flush valves with grab bars prior to installation.

1.7. ALTERNATES

- A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. WALL-MOUNTED WATER CLOSETS

- A. WC-1 Wall Hung, Exposed Manual Flush Valve
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kohler Model K-4325 Kingston
 - b. American Standard
 - c. Crane
 - d. Sloan
 - e. Zurn
 - 2. Bowl:
 - a. Material: Vitreous china
 - b. Type: Siphon Jet
 - c. Style: Flushometer Valve
 - d. Height: Standard
 - e. Rim Contour: Elongated
 - f. Water Consumption: 1.28 gal.
 - g. Spud Size; Location: NPS 1-1/2; Top
 - 3. Flushometer Valve:
 - a. Diaphragm Type: Sloan Model Royal #111-1.28, Delany, Zurn or approved equal.
 - b. Chrome plated brass.
 - c. ADA compliant non-hold open handle.
 - d. 1-inch I.P.S. screwdriver back check angle stop.
 - e. Spud coupling and flange.
 - f. Free spinning vandal resistant stop cap.
 - g. Adjustable tail piece.
 - h. High back pressure vacuum breaker flush connection.
 - i. Sweat solder adapter with cover tube and cast set screw wall flange.
 - j. Split Ring Wall Support: Sloan Model J-312-A.
 - k. Provide 3-year limited Manufacturer's warranty.

4. Toilet Seat: Kohler Model K-4670-C, American Standard 5901.100, solid plastic white seat with open front and check hinge.
 5. Carrier: Zurn, Josam, or Watts cast iron watercloset Carrier with fittings as required. ANSI/ASME A112.6.1 adjustable cast iron frame integral drain hub and vent, adjustable speed, lugs for floor and wall attachment, threaded fixture studs with nuts and washers.
- B. WC-1A Wall Hung, Exposed Manual Flush Valve, Handicapped
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kohler Model K-4325 Kingston
 - b. American Standard
 - c. Crane
 - d. Sloan
 - e. Zurn
 2. Bowl:
 - a. Material: Vitreous china
 - b. Type: Siphon Jet
 - c. Style: Flushometer Valve
 - d. Height: A.D.A. Compliant
 - e. Rim Contour: Elongated
 - f. Water Consumption: 1.28 gal.
 - g. Spud Size; Location: NPS 1-1/2; Top
 3. Flushometer Valve:
 - a. Diaphragm Type: Sloan Model Royal #111-1.28, Delany, Zurn or approved equal.
 - b. Chrome plated brass.
 - c. ADA compliant non-hold open handle.
 - d. 1-inch I.P.S. screwdriver back check angle stop.
 - e. Spud coupling and flange.
 - f. Free spinning vandal resistant stop cap.
 - g. Adjustable tail piece.
 - h. High back pressure vacuum breaker flush connection.
 - i. Sweat solder adapter with cover tube and cast set screw wall flange.
 - j. Split Ring Wall Support: Sloan Model J-312-A.
 - k. Provide 3-year limited Manufacturer's warranty.
 4. Seat: Kohler Model K-4670-C, American Standard 5901.100, solid plastic white seat with open front and check hinge.
 5. Carrier: Zurn, Josam, or Watts cast iron watercloset Carrier with fittings as required. ANSI/ASME A112.6.1 adjustable cast iron frame integral drain hub and vent, adjustable speed, lugs for floor and wall attachment, threaded fixture studs

with nuts and washers.

2.2. WALL-HUNG URINALS

- A. U-1 Wall-Hung, Exposed Manual Flush Valve
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kohler Model K-4991-ET Bardon
 - b. American Standard
 - c. Sloan
 - d. Zurn
 2. Fixture:
 - a. Material: Vitreous china
 - b. Type: Washout
 - c. Rim Height: Standard
 - d. Water Consumption: 0.125 GPF
 - e. Spud Size; Location: NPS 3/4; Top
 - f. Outlet Size; Location: NPS 2; Back
 3. Flushometer Valve:
 - a. Diaphragm Type: Sloan Model Royal #186-0.125, Delany, Zurn or approved equal.
 - b. Chrome plated.
 - c. ADA compliant non-hold open handle.
 - d. 3/4-inch I.P.S. screwdriver back check angle stop.
 - e. Spud coupling and flange.
 - f. Free spinning vandal resistant stop cap.
 - g. Adjustable tail piece.
 - h. High back pressure vacuum breaker flush connection.
 - i. Sweat solder adapter with cover tube and cast set screw wall flange.
 - j. Split Ring Wall Support: Sloan Model J-312-A.
 - k. Provide 3-year limited Manufacturer's warranty.
 4. Carrier: Zurn, Josam or Watts cast iron urinal carrier with fittings as required. ANSI/ASME A112.6.1A; cast iron and steel frame with tubular legs, legs for floor and wall attachment, threaded fixtures studs for fixture hanger, bearing studs.
- B. U-1A Wall-Hung, Exposed Manual Flush Valve, Handicapped
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kohler Model K-4991-ET Bardon
 - b. American Standard
 - c. Sloan
 - d. Zurn

2. Fixture:

- a. Material: Vitreous china
- b. Type: Washout
- c. Rim Height: A.D.A. Compliant
- d. Water Consumption: 0.125 GPF
- e. Spud Size; Location: NPS 3/4; Top
- f. Outlet Size; Location: NPS 2; Back

3. Flushometer Valve:

- a. Diaphragm Type: Sloan Model Royal #186-0.125, Delany, Zurn or approved equal.
- b. Chrome plated.
- c. ADA compliant non-hold open handle.
- d. 3/4-inch I.P.S. screwdriver back check angle stop.
- e. Spud coupling and flange.
- f. Free spinning vandal resistant stop cap.
- g. Adjustable tail piece.
- h. High back pressure vacuum breaker flush connection.
- i. Sweat solder adapter with cover tube and cast set screw wall flange.
- j. Split Ring Wall Support: Sloan Model J-312-A.
- k. Provide 3-year limited Manufacturer's warranty.

- 4. Carrier: Zurn, Josam or Watts cast iron urinal carrier with fittings as required. ANSI/ASME A112.6.1A; cast iron and steel frame with tubular legs, legs for floor and wall attachment, threaded fixtures studs for fixture hanger, bearing studs.

2.3. WALL-MOUNTED LAVATORIES

A. LAV-1 Wall-Hung, Deck Mounted Manual Faucet

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kohler Model K-2032 Greenwich
 - b. American Standard Lucerne
 - c. Crane
 - d. Zurn
- 2. Fixture:
 - a. Material: Vitreous china
 - b. Type: Wall-Hung
 - c. Rim Mounting Height: Standard
 - d. Nominal Size: 20-3/4"L x 18-1/4"W
 - e. Faucet-Hole Punching: Three Holes, 4-inch centers
 - f. Faucet-Hole Location: Top
 - g. Color: White
 - h. Mounting Material: Concealed Arm Carrier

3. Faucet:
 - a. Chicago Faucet 802-V317E66ABCP, Sloan, American Standard
 - b. Deck Mounted
 - c. Wrist Blade Handles
 - d. Low-Flow Outlet
 - e. Polished Chrome Finish
 - f. 4-inch Spout
 - g. Unit shall operate in either direction at less than 5 lbs. push at 80 psi water pressure.
 - h. Certification to comply with ADA shall be furnished
4. Strainer:
 - a. Chicago Faucet Model 327A, American Standard
 - b. 1-1/4-inch tailpiece
 - c. Non-removable brass strainer
 - d. Grid strainer waste
 - e. Chrome plated finished.
5. P-Trap:
 - a. Cast Brass 1-1/4-inch "P" trap
6. Stops:
 - a. Chicago Faucet Model 1005-ABCP valve stops.
 - b. 3/8-inch loose key cap
 - c. Removable tee handle
 - d. Wall flange
 - e. Chrome plated finished.
7. Thermostatic Mixing Valves:
 - a. Provide and install below fixture.
 - b. See Part 2 "Thermostatic Mixing Valves".
8. Carrier:
 - a. Zurn, Josam, or Watts cast iron and steel carrier.
 - b. ANSI/ASME A112.6.1
 - c. Cast iron and steel frame with tubular legs.
 - d. Lugs for floor and wall attachment.
 - e. Concealed arm supports.
 - f. Bearing plate and studs..

2.4. MULTI-STATION LAVATORIES

- A. LAV-2 Two (3) Station, Hard-wired, Infrared Sensor Faucet, Handicapped
 1. Manufacturers: Subject to compliance with requirements, provide products by one

of the following:

- a. Bradley Verge LVQD3-WB1-A50
- b. Sloan ELS-43000

2. Station:

- a. Triple hand washing station
- b. Wall Mounted
- c. Infrared type faucets with concealed vandal-resistant stream formers.
- d. Provide timing turn-off delay of 2-3 seconds.
- e. Battery Operated
- f. Low-Flow Outlet of 0.5 GPM
- g. Lavatory system shall include all waste and supply connections to wall, and thermostatic mixing valve with stop, strainer, and check valves.
- h. Bowl material for each station shall be a cast polyester resin complying with ANSI Z124.3 and ANSI Z124.6. Bowl finish shall be decorative stone.
- i. Lavatory system shall be secured to a rigid base concealing all supply and waste connections.
- j. Unit shall operate at less than 5 lbs. push at 80 psi water pressure.
- k. Certification to comply with ADA shall be furnished

2.5. MOP SINKS

A. JS-1 Mop Sink, Corner Unit

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Stern Williams Model Corlow-SBC

2. Fixture:

- a. Material: Terrazzo
- b. Type: Corner, Floor-mounted
- c. Nominal Size: 24"x24"x12"
- d. Receptor composed of pearl grey marble chips and white Portland unit, ground smooth, grouted, and sealed to resist stains.
- e. Stainless steel cap of one piece 20 gauge, 302 stainless steel cast integral on threshold.
- f. Provide and install stainless steel BP splash Catcher panels on adjacent walls.

3. Faucet:

- a. Chicago Faucet 897-RCF, Speakman, American Standard
- b. Rough Chrome Finish
- c. Vacuum breaker spout
- d. Stop in arms
- e. 3/4-inch hose thread outlet.

- f. Pail Hook
 - g. Wall Brace
 - h. Stern-Williams T-35 hose, bracket and mop hanger.
- B. JS-2 Service Sink
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kohler Model K-6716
 - b. American Standard
 - c. Ceco
 - 2. Fixture:
 - a. Material: Enameled, Cast Iron
 - b. Type: Trap Mounted
 - c. Nominal Basin Size: 24-1/4"x20-1/4"x13"
 - d. Rim Guard: Stainless Steel
 - e. Wall Hanger Supports
 - f. Provide and install stainless steel BP splash Catcher panels on adjacent walls.
 - 3. Faucet:
 - a. Chicago Faucet 305-VBRCF, American Standard
 - b. Rough Chrome Finish
 - c. Vacuum breaker spout
 - d. Adjustable Stop supply arms
 - e. 3/4-inch hose thread outlet.
 - f. Pail Hook
 - g. Vandal Proof Lever Handles
 - 4. Strainer:
 - a. Jomar Model SS-306 Snap-N-Loc basket strainer with brass locknut and tailnut.
 - b. Deep cup body and basket shall be 300 series stainless steel
 - 5. Trap:
 - a. Kohler Model K-6673, American Standard
 - b. 3-inch trap standard with cleanout

2.6. WATER COOLERS – FOUNTAINS

- A. EWC-1 Electric Water Cooler, Dual Height, Recessed Unit, Handicapped, Bottle Filling Station
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one

of the following:

- a. Elkay Model LZWS-LRPBM28K
- b. Halsey Taylor
- c. Haws

2. Fixture:

- a. Barrier Free, Recessed in wall type
- b. Dual Height with mounting frame
- c. 8 GPH at 90°F ambient
- d. 50°F outlet drinking water with 80°F inlet water
- e. Bowl shall be stainless steel
- f. Bubblers valve electronically controlled
- g. Bubblers shall be vandal resistant
- h. Activated by touch pads on sides and front for electronically timed period of flow.
- i. Cabinet shall be Stainless Steel
- j. Supplied with plug-in, 3-wire grounding type service
- k. Operation on 120 VAC, Single Phase, 60Hz
- l. Lower Spout Outlet shall be mounted 36-inches maximum above floor.
- m. Upper Spout Outlet shall be mounted 42-inches maximum above floor.
- n. Water cooler and installation shall conform to all requirements of American Disabilities Act Guidelines and ANSI A117.1.

3. Bottle Filling Station:

- a. Electronic Sensor for No-Touch activation
- b. Automatic 20 second shut-off timer
- c. 1.1 GPM flow rate with laminar flow
- d. Water Sentry® Plus, 3,000 gallon capacity filter
- e. Certified to NSF/ANSI 61, UL 399 and CAN/CSA 22.2 No. 120.
- f. Provide replacement filter pack (3 filters per pack) and turn over to Owner.

4. Refrigerant shall be R-134a or equivalent environmentally friendly refrigerant.

5. Provide Carrier as manufactured by Elkay or approved equal.

6. Provide cane apron for water cooler (required where water coolers project more than 4 inches into the corridor).

2.7. COUNTER SINKS

A. S-1 Counter Sink – Single Bowl

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkay Manufacturing Co. – Lustertone LR Series
 - b. Just Manufacturing Co.

2. Fixture:
 - a. Type: Single Bowl, Counter Mounted, Self-Rimming.
 - b. Overall Dimensions (L x W x D) inches:

31 x 22 x 8-1/8
 - c. Material: 302 Stainless Steel, 18 gauge, fully coated underside.
3. Faucet:
 - a. Standard: ASME A112.18/CSA B125.1
 - b. General: Include hot and cold water indicators; coordinate faucet inlets with supplies and fixture hold punchings; coordinate outlet with spout and sink receptor.
 - c. Model: Chicago Faucet Model 201A-GN8AE3-317ABCP
 - d. Body Type: Centerset, 8" fixed centers
 - e. Finish: Chrome Plated
 - f. Maximum Flow Rate: 2.2 gpm.
 - g. Handle(s): Model 317 Wrist Blade Handles, A.D.A. Compliant
 - h. Mounting Type: Deck, concealed.
 - i. Spout Type: Swivel gooseneck.
 - j. Spout Outlet: E3 Aerator
4. Strainer: Jomar Model SS-306 Snap-N-Loc, or Just J-35 basket strainer and brass locknut and tailnut. Deep cup body and basket shall be 300 series stainless steel. Provide 1 1/2-inch tailpiece.
5. P-Trap: Cast Brass 1 1/2 -inch "P" trap.
6. Stops: Chicago Faucets Model 1005ABCP valve stops with riser supply, 3/8-inch loose key cap and removable tee handle, wall flange, chrome plated finish.
- B. S-2 Counter Sink – Single Bowl (Handicapped)
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkay Manufacturing Co. – Lustertone LRAD Series
 - b. Just Manufacturing Co.
 2. Fixture:
 - a. Type: Single Bowl, Counter Mounted, Self-Rimming.
 - b. Overall Dimensions (L x W x D) inches:

31 x 22 x 5-1/2
 - c. Material: 302 Stainless Steel, 18 gauge, fully coated underside.

3. Faucet:
 - a. Standard: ASME A112.18/CSA B125.1
 - b. General: Include hot and cold water indicators; coordinate faucet inlets with supplies and fixture hold punchings; coordinate outlet with spout and sink receptor.
 - c. Model: Chicago Faucet Model 201A-GN8AE3-317ABCP
 - d. Body Type: Centerset, 8" fixed centers
 - e. Finish: Chrome Plated
 - f. Maximum Flow Rate: 2.2 gpm.
 - g. Handle(s): Model 317 Wrist Blade Handles, A.D.A. Compliant
 - h. Mounting Type: Deck, concealed.
 - i. Spout Type: Swivel gooseneck.
 - j. Spout Outlet: E3 Aerator
4. Strainer: Jomar Model SS-306 Snap-N-Loc, or Just J-35 basket strainer and brass locknut and tailnut. Deep cup body and basket shall be 300 series stainless steel. Provide 1 ½-inch tailpiece.
5. P-Trap: Cast Brass 1 ½ -inch "P" trap.
6. Stops: Chicago Faucets Model 1005ABCP valve stops with riser supply, 3/8-inch loose key cap and removable tee handle, wall flange, chrome plated finish.

2.8. ICE MAKER OUTLET BOX

- A. OB-1
 1. Refrigerator: Refrigerator provided in another Division of Specifications. Provide rough-in and final connection of recessed ice maker supply box. Provide shut-off valve in cold water line. Provide sufficient copper tubing to allow movement of refrigerator for cleaning.

2.9. THERMOSTATIC MIXING VALVES (INDIVIDUAL FIXTURE TYPE)

- A. Furnish and install thermostatic mixing valves where indicated at public lavatories, and below all lavatories and hand sinks that are provided with hot water temperatures above 109 degrees F.
- B. Thermostatic mixing valves shall be Bradley S59-4000A, Watts, Moen, Leonard Ecobix, Acorn, or approved equal for installation under lavatories. Provide in-line check valves, lead free body, escutcheon plates, inlet filters, and insulation as required. Thermostatic mixing valves shall be adjusted to deliver 105 degrees Fahrenheit hot water when supplied with 140 degrees Fahrenheit delivering hot water. Furnish with adjusting cap with locking feature.
- C. The thermostatic mixing valves shall be listed for use at the scheduled flow rate of the

equipment served.

- D. The thermostatic mixing valves shall be ASSE standard 1070 listed.

2.10. PLUMBING FIXTURE SUPPORTS

- A. Wall mounted urinal supports, Josam 17810 plate type with cast iron headers, box steel stanchions, block type cast iron feet with bearing plate.
- B. Support for wall mounted urinals, lavatories, sinks, drinking fountains, etc.:
- C. Where fixtures are supported from concrete or cinder block walls, install No.10 USSG Steel plate on the opposite side of the wall and bolt hangers or supports through plate. Where opposite side of wall is exposed to view, place bolts in core of blocks and fill core with cement.
- D. Where lavatories with wall hangers have been specified and fixtures are supported from metal stud frame partitions, fixture brackets or mounting lugs shall be through bolted to steel channel crosspieces not less than 1-1/2-inch wide anchored to studs. Bolt heads shall be welded to channel web.
- E. Concealed arm type lavatory supports, Josam 17100 with cast iron headers, box steel stanchions, block type cast iron feet and header; and chrome plated cast brass threaded escutcheons for slab type lavatories.
- F. Flush mounted drinking water cooler supports, Josam 17550 plate type, box steel stanchions, block type cast iron feet.
- G. Water closet chair carriers, Josam 12000 Series for horizontal and vertical installations.

2.11. HANDICAPPED LAVATORY/SINK INSULATION

- A. All handicapped lavatories and sinks shall be provided with under counter pipe and trim insulation.
- B. Insulation shall be fully molded "P" trap and angle valve insulated Hand-I-Lav Guard, Truebro, Pro-Extreme Model #101, 102, and 105 to suit.
- C. Insulation to meet ADA #4 19.4, ANSI A117.1, ASTM C1822, Type III and International Plumbing Code.
- D. Self-extinguishing ASTM D635 burn characteristics, thermal conductivity ASTM C177 K-Value ' 1.17.
- E. Insulation thickness to be minimum 2 inch.
- F. Where lav. Guards are provided insulation may be omitted.

2.12. FIXTURE STOPS/SUPPLIES

- A. For all lavatories/sinks stops and supplies shall be Chicago Faucets No. 1017-CR43829, Angle Stop Fitting with Supply Tube and Loose Key, Chrome plated solid brass

construction. 2-1/4" Metal tee handles with tapered square. Slow compression check cartridge that shall open and close 360° for fine adjustment, valves shall close with water pressure, furnish with square tapered stem. 1/2" NPT female thread inlet 3/8" O.D. female compression outlet. Slip wall flange. 3/8" O.D. x 12" bullnose flexible supply riser. ECAST construction with less than 0.25% lead content by weighted average. This product shall be tested and certified to industry standards: ASME A112.18.1/CSA B125.1, Certified to NSF/ANSI 61, Section 9 by CSA, California Health and Safety Code 116875 (AB1953-2006), Vermont Bill S. 152, and NSF/ANSI 372 Low Lead Content.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

- A. Install all equipment in accordance with manufacturer's instructions.
- B. Setting heights of lavatories, drinking fountains, etc., shall be as directed prior to installation and shall be coordinated with Architectural Contract Documents.
- C. Install floor mounted fixtures only after finished floor has been installed.
- D. Provide rubber concussion washers between vitreous china fixtures and supporting brackets.
- E. Protect chromium plated trim from corrosive solutions used to clean tile work.
- F. Provide white, silicone caulking where fixtures come in contact with walls and floors. Sealant shall be mildew resistant type in accordance with ANSI A-136.1.
- G. Install components plumb and level.
- H. Install and secure fixtures in place with wall supports, wall carriers and bolts.
- I. Solidly attach water closets to floor with lug screws. Lead flashing is not intended to hold fixture in place.
- J. Install flush valve handles on the open side of all ADA waterclosets in accordance with ANSI requirements.
- K. Fixtures shall be vitreous china unless otherwise noted. Cast iron fixtures shall have acid resisting enamel finish unless noted otherwise, color shall be white.
- L. Flush valves shall be self-closing, non-hold open type with vacuum breaker and perform satisfactorily when subject to inlet water pressure varying from 15 to 75 psi. Flush valves shall be as specified, Sloan, Delaney, Zurn, Toto, or approved equal.
- M. Provide flexible risers and loose key stops for all lavatories and sinks. Provide 17 ga. chrome plated brass tail piece and trap with cleanout for all lavatories and sinks.
- N. Coordinate with plumbing piping and related fuel piping, gas venting and electrical work to achieve a complete operating system.
- O. Field test all emergency eyewash units and combination eyewash/shower units per ANSI

Z358.1 latest edition.

- P. All plumbing vents within a 10'-0" radius of exhaust vents shall be extended to a height of 3'-0" above exhaust vent crown.
- Q. All plumbing vents within a 10'-0" radius of any rooftop unit or intake louver shall be extended to a height of 3'-0" above fresh air intake.
- R. Slopes and invert elevations of all interior piping shall be established before any piping is installed in order that proper slopes will be maintained. All piping shall be located and determined where to be run to avoid conflict with other trades.
- S. Unless otherwise noted, all plumbing piping shall be routed as high as possible between bottom of roof joists and above ceiling to allow proper installation of ductwork, fire protection piping, conduits, etc.
- T. Coordinate with Architectural Drawings before roughing in plumbing.
- U. All openings in ceilings and plenum walls for plumbing shall be sealed air tight and protected with fire stop.
- V. See site plan for extent of all piping leaving and entering building.
- W. See domestic water riser diagrams for location of valves, shock absorbers, etc.
- X. Make proper HW, CW, re-cir., waste, and vent connections to all fixtures and equipment even though all branch main, elbows and connections are not shown.
- Y. Unless otherwise noted, sanitary waste piping shown is below floor and all other piping is overhead, above ceiling. Domestic hot, cold and re-circ. water piping shall be installed between ceiling and attic insulation.
- Z. Unless otherwise noted, horizontal sanitary piping shall be pitched 1 percent.
- AA. Unless otherwise noted, all domestic water piping and fire protection piping shall be installed on heated side of ceiling insulation.
- BB. All piping and installation shall comply with all local and national plumbing codes. Test piping as required by plumbing code and authority having jurisdiction.
- CC. For sizes of all domestic water piping see plumbing fixture schedule and domestic water riser diagrams.
- DD. For sizes of all sanitary and vent piping see plumbing fixture schedule and sanitary/vent riser diagrams.

3.2. PLUMBING SPECIALTY INSTALLATION REQUIREMENTS

- A. General: Install plumbing specialty components, connections, and devices according to

manufacturer's written instructions.

- B. Fasten recessed, wall-mounting plumbing specialties to reinforcement built into walls.
- C. Secure supplies to supports or substrate.
- D. Install individual stop valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve as appropriate is not indicated.
- E. Install water-supply stop valves in accessible locations.
- F. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.
- G. Include wood-blocking reinforcement for recessed and wall-mounting plumbing specialties.

3.3. FITTINGS FOR FIXTURES SUPPLIED BY OTHERS

- A. Fixtures such as built-in-sink in counters and kitchen equipment are provided under other divisions of the specifications and are complete with strainer and tailpiece. Fittings, accessories and connection of these fixtures to the plumbing system are provided under this section.
- B. Rough-in and final connection includes but is not limited to all domestic water, waste, vent, systems. Furnish stops, strainers, vacuum breakers, and under counter insulation where not furnished under another Division of these specifications.

3.4. TESTING

- A. After plumbing fixtures are connected, all piping and fixtures shall be tested for operation and a smoke or peppermint test shall be made on all soil, waste and vent piping.
- B. After the building has been occupied and the various equipment is in actual use, the Contractor shall make an operating test of all equipment at a time directed by the Engineer to determine that all contract requirements are met.

3.5. CLEANING AND STERILIZATION

- A. After final testing for leaks, all potable water lines shall be thoroughly flushed, by plumbing contractor, to remove foreign material. Before placing the systems in service, sterilize the new water lines in accordance with local health department codes and at a minimum according to the following procedure:
- B. Through a 3/4-inch hose connection in each branch main and building main, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 ppm. Plumbing Contractor shall provide plumbing connections and power for pumping chlorine into system.
- C. Proceed upstream from the point of chlorine application opening all faucets and taps until

chlorine is detected. Close faucets and taps when chlorine is evident.

- D. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 ppm chlorine, retain this water in the system for at least three (3) hours.
- E. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system. It is not necessary to retain chlorine in any system for twenty-four hours to achieve sterilization. AWWA states that 200 ppm chlorine for three hours is sufficient.
- F. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.
- G. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 ppm.
- H. Obtain representative water sample from the system for analysis by an independent and recognized bacteriological laboratory.
- I. If the sample tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the service organization to the Contractor, certifying successful completion of the sterilization. Additionally, this report shall be forwarded to the Owner as well as be included in the O&M Manual.
- J. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.
- K. Take precautions to avoid use of plumbing fixtures and domestic water systems during sterilization period. Place signs on all plumbing fixtures and outlets during sterilization period.

3.6. EXAMINATION

- A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B. Verify that electric power is available and of the correct characteristics.

3.7. PREPARATION

- A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.8. INTERFACE WITH OTHER PRODUCTS

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.9. ADJUSTING

- A. Adjust stops and valves for intended water flow rate to fixtures without splashing, noise,

or overflow.

3.10. CLEANING

- A. At completion, clean plumbing fixtures and equipment. Polish all chrome plated faucets, accessories, equipment, and piping.
- B. All electric water cooler coils shall be cleaned of all construction dust and debris prior to building occupation by Owner.

3.11. FIXTURE HEIGHTS

- A. Install fixtures to heights above finished floor as required by local Plumbing Code, Americans with Disabilities Act (A.D.A.), Authority Having Jurisdiction, and Architectural Contract Drawings. In the absence of a local code requirements, install fixtures to heights above finished floor as follows.
- B. Water Closet
 - a. Standard 15 inches to top of bowl rim.
 - b. Handicapped 18 inches to top of seat.
- C. Urinal
 - a. Standard 22 inches to top of bowl rim.
 - b. Handicapped 17 inches to top of bowl rim.
- D. Lavatory
 - a. Standard 31 inches to top of basin rim.
 - b. Handicapped 34 inches to top of basin rim.
- E. Drinking Fountain
 - a. Standard 36 inches to top of basin rim.
 - b. Handicapped 34 inches to top of basin rim.
- F. Water Closet Flush Valves
 - a. Standard 11 inches min above bowl rim.
 - b. Recessed 10 inches min. above bowl rim.
- G. Combination Emergency Shower/Eye Wash
 - a. Handicapped 84 inches to bottom of shower head and 38 inches to eye wash receptor rim.

END OF SECTION

DIVISION 22 SECTION 22 40 05
PLUMBING EQUIPMENT
TABLE OF CONTENTS

PART 1. GENERAL.....	1
1.1. GENERAL.....	1
1.2. REFERENCES	1
1.3. DELIVERY, STORAGE, AND HANDLING.....	2
1.4. FIELD MEASUREMENTS	2
1.5. ALTERNATES	2
PART 2. PRODUCTS.....	2
2.1. FLOOR AND ROOF DRAINS.....	2
2.2. CLEANOUTS	4
2.3. EXTERIOR NON-FREEZE WALL HYDRANTS	4
2.4. INTERIOR RECESSED WALL HYDRANTS	5
2.5. SHOCK ABSORBERS.....	5
2.6. VACUUM BREAKERS.....	5
2.7. HOSE BIBBS	6
2.8. BACKWATER VALVES	6
2.9. BACKFLOW PREVENTER (REDUCED PRESSURE PRINCIPAL TYPE).....	6
2.10. TRAP PRIMING STATION-AUTOMATIC TRAP PRIMER.....	7
2.11. TRAP SEAL PRIMER VALVES.....	8
2.12. THERMOSTATIC MIXING VALVES (INDIVIDUAL FIXTURE TYPE).....	8
2.13. ELEVATOR PIT SUMP PUMP	8
PART 3. EXECUTION.....	12
3.1. GENERAL INSTALLATION REQUIREMENTS	12
3.2. PLUMBING SPECIALTY INSTALLATION REQUIREMENTS.....	14
3.3. FITTINGS FOR FIXTURES SUPPLIED BY OTHERS	15
3.4. TESTING.....	15
3.5. CLEANING AND STERILIZATION	15
3.6. EXAMINATION.....	16
3.7. PREPARATION.....	16
3.8. INTERFACE WITH OTHER PRODUCTS	16
3.9. CLEANING.....	16
END OF SECTION	16

SECTION 22 40 05

PLUMBING EQUIPMENT

PART 1. GENERAL

1.1. GENERAL

- A. For General Mechanical Requirements, see Division 22 Section, Common Work Results for Plumbing & Division 01, General Requirements.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specifications apply to this Section.
- C. All exposed bolts, screws, etc., shall be vandal proof.
- D. All plumbing materials and equipment shall be new and of best grade, free of defects and complete with all required appurtenances and accessories.
- E. Piping and insulation are specified under other sections.
- F. Provide all materials, equipment and perform all labor required to install plumbing system complete as specified, as drawings indicated and as required by the State of Delaware, National Standard Plumbing Code , International Plumbing Code, City of Dover Code, the local code, and all other authorities have jurisdiction.
- G. Provide stops for all plumbing equipment. Stops are to be accessible.
- H. Provide pumps with manufacturer's name, model number, and rating/capacity identified.
- I. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:
 - 1. American Gas Association (AGA).
 - 2. National Sanitation Foundation (NSF).
 - 3. American Society of Mechanical Engineers (ASME).
 - 4. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).
 - 5. National Electrical Manufacturers' Association (NEMA).
 - 6. Underwriters Laboratories (UL).
- J. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitations, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.

1.2. REFERENCES

- A. ANSI/ASSE 1011 - Hose Connection Vacuum Breakers.

- B. ANSI/ASSE 1013 - Backflow Preventers, Reduced Pressure Principle.
- C. ANSI/ASE 1019 - Wall Hydrants, Frost Proof Automatic Draining Anti-Backflow Types.
- D. ANSI A112.21.1 - Floor Drains.
- E. ANSI A112.21.2 - Roof Drains.
- F. ANSI A112.26.1 - Water Hammer Arrestors.
- G. AWWA C506 - Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types.
- H. PDI WH-201 Water Hammer Arresters.
- I. ANSI/ASHRAE 90A - Energy Conservation in New Building Design.
- J. ASME Section VIII D - Pressure Vessels; Boiler and Pressure Vessel Codes.
- K. ANSI/NFPA 54 - National Fuel Gas Code.
- L. ANSI/NFPA 70 - National Electrical Code.
- M. IBC - International Building Code

1.3. DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of General Requirements.
- B. Accept equipment on site in factory packaging. Inspect for damage.
- C. Protect installed equipment from damage by securing areas and by leaving factory packaging in place to protect equipment and prevent use.

1.4. FIELD MEASUREMENTS

- A. Verify that field measurements are as indicated on shop drawings and per the manufacturer.

1.5. ALTERNATES

- A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. FLOOR AND ROOF DRAINS

- A. Provide Nikaloy strainers on all floor drains unless specified otherwise.
- B. Provide flashing clamps on all drains penetrating waterproofing membrane.

- C. Provide suitable flashing material and clamping collar for drains which are not set in place when slab is poured.
- D. Provide backwater valves for all floor drains connecting directly to the storm water system. Depending on conditions of the particular installation backwater valves may be an integral part of the drains or a separate device. Accessibility to valves must be maintained for maintenance. Provide an adequately sized extension sleeve up to floor or grade as required.
- E. Backwater valves are normally closed, flapper type with bronze or brass seat and disc and stainless steel pin.
- F. Provide traps for all floor drains connected to the sanitary system.
- G. Provide E & S primer valve (one valve per trap, per floor drain) on all remote floor drains. When installed on fixture in finished area, primer valve shall be concealed behind a Josam 58650 access door. In Mechanical Rooms, mezzanines, penthouses, and all other locations indicated on the contract drawing, priming lines shall be connected to automatic trap primer.
- H. Provide Josam 26200 vertical expansion joint in each rain leader that does not have 90 degrees offset downstream of the roof drain. The expansion sleeve shall be bronze and shall conduct the rain water beyond the packing. Install expansion joints in accessible locations for repacking.
- I. In lieu of joints specified in piping section, neoprene gaskets may be used if designed for use with the drains and cleanouts employed and if approved by the local plumbing authority.
- J. Where applicable, for floor drains utilized for washing machines, provide a stainless steel lint screen/strainer.
- K. Schedule of Drains and Accessories:
 - 1. SD-1: Combination Roof Drain/Overflow Drain: Zurn Z-163 15-inch diameter roof drain and overflow drain, Dura-Coated cast iron bodies with combination membrane flashing clamp/gravel guards, double Top-Set deck plate and low silhouette aluminum locking domes. Provide with support rings, adjustable tops with wide roof flanges, 24"x42" large galvanized sump receiver with anchor flange, bottom outlets inside caulk connections and deck clamps. Provide Overflow Drain with 2" high internal water dam.
 - 2. SD-2: Roof Drain: Zurn Z-100 15-inch diameter roof drain, dura coated cast iron body with combination membrane flashing clamp/gravel guard and low silhouette aluminum locking dome. Provide with support ring, adjustable top with wide roof flange, large sump with anchor flange, bottom outlet inside caulk connection and deck clamp. Provide overflow drain as detailed on contract drawings.
 - 3. SD-3: Downspout Nozzle: Zurn Z-199 Downspout Nozzel, all nickel bronze body, threaded inlet and decorative face of wall flange and outlet nozzle. Provide removable stainless steel screen. Size to match overflow drain pipe size. Color to be selected by Architect.

4. FD-1: General Service Floor Drain: Zurn ZN-415 floor and shower drain, dura coated cast iron body with bottom outlet, combination invertible membrane clamp and adjustable collar with Type "B" polished nickel bronze strainer. Provide with ½ -inch trap primer connection.
5. FD-2: Mechanical Room Floor Drain: Zurn Z-566 12-inch square open top drain, dura coated cast iron body with bottom outlet, ½ top grate, large suspended cast iron sediment bucket. Provide flashing flange and ½" -inch trap primer connection.

L. Approved Manufacturers: Josam, J.R. Smith, Zurn, Wade, Ancon, Mifab, Watts.

2.2. CLEANOUTS

- A. Provide cleanouts in sanitary and storm drainage systems at ends of runs, at changes in direction, near the base of stacks, every 50 feet in horizontal runs, of 4-inch diameter or less, every 100 feet in horizontal runs over 4-inches, and where indicated.
- B. Cleanouts shall be full size of pipe up to 4-inches and shall be 4-inches for larger sizes. Where installed in finished floors inserts shall match adjacent floor construction.
- C. Materials and Approved Manufacturers: Josam, J.R. Smith, Zurn, Wade or Ancon, Mifab, Watts, equal to Josam numbers given below:

- | | | |
|-----|--|------------|
| 1. | Concealed Piping | C.I. Pipe |
| 2. | Unfinished Areas | |
| 3. | Floors | 57000-Z-CI |
| 4. | Walls | 58600-PLG |
| 5. | Finished Areas Floors | |
| 6. | Terrazzo | 56040-13 |
| 7. | Composition Tile | 57000-X-12 |
| 8. | Ceramic Tile | 57000-X |
| 9. | Carpet | 56070-14 |
| 10. | Carpet insert to match adjacent carpet in type, color and grade. | |
| 11. | Finished Areas Walls | |
| 12. | Plaster/Dry Wall | 58640-COT |
| 13. | Tile/CMU | 58600-COT |

2.3. EXTERIOR NON-FREEZE WALL HYDRANTS

A. HYD-1 Exterior Non-Freeze Wall Hydrant

1. Wall Hydrant (Exterior): Josam 71000 Series Hydrasan anti siphon wall hydrant, 3/4-inch non-freeze, key operated wall hydrant with hinged locking cover, polished bronze box and cover and bronze casing and integral vacuum breaker. Seat and disc shall be removable from front of the hydrant. Wall thickness; see architectural drawings. Wall hydrants shall conform to ANSI/ASSE 1019 with wall plate, lock shield and removable key.
2. Approved Manufacturers: Josam, Wade, Zurn, J.R. Smith, Mifab, Watts, or approved equal.

2.4. INTERIOR RECESSED WALL HYDRANTS

A. HYD-2 Interior Recessed Wall Hydrant

1. Provide and install recessed wall hydrants where indicated on the contract drawings. Recessed wall hydrants shall be Zurn Model Z 1330, Josam, Ancon, Mifab, Watts or approved equal.
2. Units shall be encased Ecotrol "anti-siphon" wall hydrant for interior wall installation. Unit shall be suitable for hot or cold water as indicated on Contract Drawings.
3. Each unit shall be complete with integral backflow preventer, all bronze interior parts, non-turning operating coupling with hemispherical neoprene plunger and 3/4-inch solder inlet.
4. Furnish each unit mounted in a stainless steel box and hinged cover with operating key lock and "water" stamped on cover.
5. Furnish each unit with the following accessories:
 - a. 3/4 inch – 90 degrees inlet elbow with union nut
 - b. Cylinder lock
 - c. Key operator

2.5. SHOCK ABSORBERS

- A. Provide shock absorbers equal to Josam Shokstops at all fast closing valves, at the top of all cold water risers, at each flush valve or battery of flush valves, and where indicated. Sizes and locations shall be in accordance with PDI Standard WH 201.
- B. Shock absorbers shall conform to ANSI A112.26.1, precharged suitable for operation in temperature range -100 to 300 degrees F and maximum 250 psig working pressure.
- C. Approved Manufacturers: Josam, Wade, Zurn, J.R. Smith, Sioux Chief, Watts, or approved equal.

2.6. VACUUM BREAKERS

- A. Provide vacuum breakers on water connections to fixtures and equipment where minimum

air gaps required by Plumbing Code are not possible and on hose bibbs and other outlets to which hoses can be attached.

- B. Vacuum breakers not subject to back pressure, Watts No. 288A; vacuum breakers subject to back pressure, Watts Series 9D or for hose threads, Watts Series 8A.
- C. Provide atmosphere vacuum breakers at all water connections to garbage disposers, hose spray units as required by Plumbing Code.
- D. Hose connection backflow preventers shall be ASSE 1052, suitable for at least 5 gpm flow and applications with up to 10 foot head back pressure. Include two (2) check valves, intermediate atmospheric vent, and non-removable, ASME B1.20.7 garden-hose thread on outlet.
- E. Hose connection vacuum breakers shall be ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7 garden-hose threads on outlet. Units attached to rough-bronze finish hose connections may be rough bronze.
- F. Approved manufacturers: Watts, Beeco, B&K Industries, Zurn, Sparco, Conbraco or approved equal.

2.7. HOSE BIBBS

- A. Chicago Faucet No. 952 or approved equal hose and faucet. Bronze or brass with integral mounting flange, replaceable hexagonal disc, hose threaded spout, polished chrome plated where exposed in finished areas, with hand wheel and removable key, integral vacuum breaker in conformance with ANSI/ASSE 1011.
- B. Hose bibbs in finished areas shall be polished chrome finish.
- C. Approved Manufacturers: Chicago Faucet, American Standard, Crane, T&S Brass, Watts.

2.8. BACKWATER VALVES

- A. Backwater valves shall be provided at all connections of floor drains or area drains to stormwater piping systems and where indicated on contract drawings.
- B. Backwater valves shall be ANSI A112.21.2, coated cast iron body and cover, brass valve, access cover, extension sleeve and cover.
- C. Backwater valves shall be equal to Josam 67360-15.
- D. Extend access cover to finished floor and terminate in cleanout.
- E. Approved Manufacturers: Josam, Zurn, Wade, Smith, Ancon or approved equal.

2.9. BACKFLOW PREVENTER (REDUCED PRESSURE PRINCIPAL TYPE)

- A. Furnish and install reduced pressure principal backflow preventers at all cold water make-up connections to HVAC water systems and where indicated on contract drawings.
- B. Backflow preventers shall be of bronze body construction, inlet and discharge OS&Y gate

valves, stainless steel check and relief valve seats, stainless steel relief valve shafts and flange bolts. Ball valve test cocks shall be bronze body.

- C. Pressure ratings shall be up to 175 psi and temperature ratings shall be up to 210 degrees F continuous.
- D. Install unit per local code requirements and authorities having jurisdiction. Unless otherwise noted, install backflow preventers between 12 inches and 60 inches above finished floor.
- E. Units shall be approved by ASSE 1013, UPC, UL, and shall be No. 909 with air gap fitting and inlet/outlet gate valves as manufactured by Watts Regulator, Conbraco, Wilkens, or as approved equal. Pipe discharge to nearest floor drain/floor sink. Provide minimum 18-inch clearance for servicing and testing.
- F. Pipe discharge of backflow preventer full size to closest floor drain utilizing type "L" copper.
- G. Furnish test kit for field testing units. Watts Model TK-9A Analog Differential Gauge or approved equal.

2.10. TRAP PRIMING STATION-AUTOMATIC TRAP PRIMER

- A. Trap priming stations shall be Precision Plumbing Products, Inc., Electronic Trap Priming manifold Model PT. The manifold shall supply a minimum of 2 ounces of potable water per opening at 20 PSIG once in each 24 hour period. The Electronic Trap Priming Manifold must be capable of equally priming from 4 through 30 individual floor drain traps.
- B. The unit shall be factory assembled and prepiped, and shall include a bronze body 3/4-inch female NPT WOG rated ball valve 3/4-inch, Water Hammer Arrestor, copper barrel with brass piston and type "L" copper sweat connection, electronic brass body 3/4-inch solenoid valve, and type "L" copper manifold with brass 2-inch compression fitting and orifice opening for precision water distribution to each floor drain trap. Unit shall be pre-piped with atmospheric vacuum breaker.
- C. Electronic components shall include single point power connection at 120 volt 1 phase 60 hertz, manual over-ride switch, minimum 5 amp breaker, 24 hour geared timer with relay and 5 second dwell function.
- D. All components shall be factory assembled, tested and supplied in a 16 gauge steel enclosure suitable for surface or recess mounting, as indicated on contract drawings. In addition, all components must comply with nationally recognized standards. The Precision Plumbing Products Electronic Trap Priming Manifold shall be fully warranted for the life of the plumbing system.
- E. When only a single trap primer is required, as in the case of a restroom with one floor drain in a toilet (or similar) the contractor may submit, in lieu of an electronic multiple station, a single station for review by the Engineer. The fixture serving the trap primer must be within 10' of the trap. Components shall be brass, bronze, and chrome, of the highest quality.

- F. Access door shall be finished with a prime coat and fire rated where installed in a rated wall. Access door latch shall be Allen key type.

2.11. TRAP SEAL PRIMER VALVES

- A. Provide and install one valve per trap, per floor drain on all remote floor drains. When installed on a fixture in a finished area, primer valve shall be concealed behind an access door. In mechanical rooms, mezzanines, penthouses, and all other locations indicated on contract drawings, priming lines shall be connected to automatic trap primer station. Trap seal primer valves shall be as manufactured by E&S, Precision Plumbing Products, Sioux Chief, Mifab, Watts, or approved equal.
- B. Trap seal primer valves shall be ASSE 1018, water supply fed type with the following characteristics:
 - 1. 125 psig minimum working pressure.
 - 2. Bronze body with atmospheric - vented drain chamber.
 - 3. Inlet and outlet connections: ½ inch NPS threaded or solder joint.
 - 4. Gravity drain outlet connection: ½ inch NPS threaded or solder joint.
 - 5. Finish: chrome plated

2.12. THERMOSTATIC MIXING VALVES (INDIVIDUAL FIXTURE TYPE)

- A. Furnish and install thermostatic mixing valves where indicated at public lavatories, and below all lavs/handsinks that are provided with hot water temperatures above 109 degrees F.
- B. Thermostatic mixing valves shall be Bradley S59-4000A, Watts, Acorn, or approved equal for installation under lavs. Provide in-line check valves, lead free body, escutcheon plates, inlet filters, and insulation as required. Thermostatic mixing valves shall be adjusted to deliver 105 degrees Fahrenheit hot water when supplied with 140 degrees Fahrenheit delivering hot water. Furnish with adjusting cap with locking feature.
- C. The thermostatic mixing valves shall be ASSE standard 1070 listed.

2.13. ELEVATOR PIT SUMP PUMP

- A. Furnish and install an elevator pit submersible sump pump of the size, capacity and electrical characteristics as shown on the drawings. System shall include submersible pump, 2-inch discharge flange/piping, grate with cover, float switches, oil sensor, remote mounted control panel and control system. Pumps and accessories shall be by Stancor Oil Minder, Zoeller, Liberty, Bell & Gossett, or approved equal.
- B. Pumps:
 - 1. Pump Design: The pump shall be capable of handling clean water waste. The pump(s) shall be capable of handling liquids with temperatures to 104 degrees F continuous, 160 degrees F intermittent, and shall be capable of running dry for

extended periods. Pump shall include thermal and overload protection.

C. Pump Construction:

1. The volute, seal plates, impeller and motor housing shall be constructed of high quality #304 stainless steel. The pump(s) shall be painted with a water based air dry enamel of 2.0 mil minimum thickness. All exposed hardware shall be 300 series stainless steel. The pump construction shall contain no points of critical clearance nor require periodic adjustment or replacement to maintain operating efficiency. Discharge connection shall be a standard 2-inch NPT in the vertical position. All gaskets shall be of the compression square ring type eliminating critical slip fits and the possibility of damage during service associated with sliding o-ring sealing arrangements.
2. The impeller shall be of the non-clog design with pump out vanes on the back side. The impeller shall be dynamically balanced to ISO G6.3 specifications.
3. The unit shall utilize a single mechanical shaft seal which shall operate in an oil atmosphere. The materials of construction shall be carbon for the rotating face and ceramic for the stationary face, lapped and polished to a tolerance of one light band, 300 series stainless steel hardware, and all elastomer parts to be of Buna-N. The seal shall be commercially available and not a proprietary design of the manufacture.
4. The pump shall be designed to be non-overloading throughout the entire pump curve. The rotor and stator assembly shall be of the standard frame design and secured to the pump seal plate by four threaded fasteners allowing for easy serviceability. Motor designs incorporating shrink or press fit assembly between the stator and motor housing shall not be acceptable. The motor shall be constructed with the windings operating in a sealed environment containing clean dielectric oil, making it capable of operating in a totally, partially or non-submerged condition for extended periods of time without damage due to the heat being generated. Air-filled motors shall not be acceptable. The motor windings shall be of Class "F" insulation. The motor shall meet the standard NEMA design L for single phase and NEMA design B for three phase. The motor shaft shall be of 416 stainless steel. The lower bearing shall be of the single ball type to accept radial and thrust loads, and the upper bearing of the sleeve or ball design, for radial loads. Bearings shall operate in an oil bath atmosphere for superior life. Permanently lubricated bearings are not acceptable.
5. Thermal sensors shall be used on three phase units to monitor stator temperatures. The stator shall be equipped with a thermal switch embedded in the end coil of the stator winding. This shall be used in conjunction with external motor overload protection and wired to the control panel. Single phase shall have an overload switch on the motor windings and do not require any external protection.
6. The pump shall be equipped with type neoprene jacketed power cable and connected to the motor via quick disconnect spade terminals length as required. Crimp connected cords are not acceptable. Heat shrink tubes shall be used to connect power cord leads with motor leads. A master heat shrink tube shall be provided and filled with epoxy to seal the outer cable jacket and the individual

strands to prevent water from entering the motor housing. A secondary rubber pressure grommet shall be provided as an additional sealing point and strain relief at the point of cable entry. Cable entry designs utilizing terminal boards to connect power cord leads with motor leads shall not be acceptable.

7. The sump grate shall be custom sized to accommodate the dimensions of the sump. Grate shall be galvanized steel and have openings for all pipes/conduits as required.

D. Pump Test:

1. The pump manufacturer shall perform the following inspections and tests in accordance with Hydraulic Institute type B standards before shipment from the factory.
2. A check of the motor voltage and frequency shall be made as shown on the name plate.
3. A motor and cable insulation test for moisture contents or insulation defects shall be made per UL criteria.
4. The pump shall be completely submerged and run to determine that the unit meets three pre-determined hydraulic performance points.
5. A written report shall be available showing the aforementioned tests have been performed in accordance with the specifications.

E. Start-Up:

1. The pump(s) shall be tested at start-up by a qualified representative of the manufacturer. A start-up report as provided by the manufacturer shall be completed before final acceptance of the pump(s).
2. Warranty: Two (2) years from substantial completion.

F. Float Level Controls:

1. Provide and install three (3) level controls as detailed on the drawings. Two (2) level controls shall be utilized for the pump operation and the remaining level control shall be utilized for high water level alarm. Level controls shall be provided in a pipe mounted configuration with 25 feet of cable. Level controls shall be pilot duty devices which shall control the function of motor load devices, contactors, motor starters and power relays, to automatically cycle pumps. Switches shall be rated at 4.5 Amps at 115 VAC RES, Provide pole and stainless steel clamps and hardware.
2. Where required, provide custom length of cables to accommodate distance between sumps and control panels where the minimum 25 feet length is insufficient.

G. Valves:

1. Provide and install discharge valves on the pump as detailed on the drawings. Ball check valves shall be provided with removable threaded plug and natural rubber ball. Valve body shall be ASTM class 30. Cast iron valve shall be able to withstand 150 psig.
2. Ball Valves:
 - a. Ball valves shall be True Union Type manufactured of Type 1 Schedule 80 PVC with EPDM O-rings for superior chemical and corrosion resistance. Valves shall be quick disconnect type for ease of maintenance. Ball valves shall be suitable for pressures up to 150 psig.

H. Control Panel:

1. The pump manufacturer shall supply a completely self-contained motor control panel. The control panel shall be provide with short circuit and overload protection for the pump. Furnish control panel with 8 pin twist lock receptacle, dual solid state oil sensor relays with reliable sensitivity settings, over current relay, sensor probe, horn, alarm silencing switch, terminal board and remote monitoring contacts. Furnish sufficient cable between pump and control panel. Furnish sufficient cable and plug for the control panel.
2. The motor controls shall be housed in a NEMA 4X enclosure. The enclosure shall be formed of 16 or 14 gauge, G-90 galvanized steel, with all surfaces phophatized then finished inside and out with ANSI 61 gray polyester powder finish. The door shall be equipped with two galvanized hinges with stainless steel hinge pins. The enclosure shall have external mounting tabs for wall mounting.
3. A magnetic starter shall be provided for each pump motor. The starter shall be equipped with a three (3) pole bimetalic overload relay with ambient compensation and Class 10, quick trip heaters. Heaters must be properly sized for motor load. The overload relay shall provide the terminals for connection of the pump motor cable.
4. A control transformer shall be provided to supply low voltage as required for the control circuit. The transformer shall be continuous duty machine tool type, size to meet the load requirements of the control circuit. The transformer primary shall be connected to the load side of the circuit breaker. One side of the secondary winding shall be grounded to the component mounting panel.
5. A terminal block shall be provided for connection of level controls, oil sensor, alarms, remote monitoring and other control wiring as required for proper pump installation.
6. Control panel shall be interlocked with floats and oil sensor to allow pumping of water while containing oil. Control panel shall be fully automatic and shall provide for an alarm and LED lights in the event of any of the following:
 - a. Presence of oil in the sump.

- b. High water level.
 - c. High amps.
 - d. Locked rotor.
7. Furnish additional contacts/relays for remote monitoring of high water alarm and oil presence alarm on facility automatic temperature control system. Coordinate with Division 23 Section, Instrumentation and Controls of HVAC and Plumbing Systems.
8. The control panel shall be wired in accordance with all applicable requirements of the National Electrical Code. Control wiring shall be sixteen (16) AWG red for control circuits and white for neutral grounded conductors. Power wiring shall be a minimum of 14 AWG black. Each conductor shall be numbered. The ends of all wires shall be tinned with 60/40 lead tin alloy sold. All wiring shall be performed in a neat and orderly manner.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

- A. Install all equipment in accordance with manufacturer's instructions.
- B. Install components plumb and level.
- C. Cleanouts in vertical pipes shall be installed in tees near floor. Cleanouts in horizontal pipes shall be installed with wyes on long sweep quarter beds. Cleanouts punching water proofing membranes shall have flashing clamps. Cleanout access covers in dry wall or gypsum board shall be painted to match walls.
- D. Unless otherwise noted, drains are to be installed at the low point of floors. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- E. Install floor drains in low points so the top of grates are at or below the finished floor level.
- F. Drains not functioning properly shall be removed and re-installed properly at the expense of the contractor.
- G. Coordinate cutting and forming of roof and floor construction to receive drains to required invert elevations.
- H. Extend cleanouts to finish floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
- I. Encase exterior cleanouts in concrete flush with grade.
- J. Install water heaters in accordance with manufacturer's instructions and to AGA, NSF, ANSI/NFPA 54, UL requirements and Delaware Boiler and Pressure Vessel Safety Act and Regulations. For gas fired water heaters, conduct a combustion flue gas analysis. Submit flue gas analysis report to Engineer for review. Record and submit design and

actual draft at appliance vent connection.

- K. All plumbing, vents in exterior walls shall be offset a minimum of 3'-0" in ceiling at roof before penetration.
- L. All plumbing vents within a 10'-0" radius of exhaust vents shall be extended to a height of 3'-0" above exhaust vent crown.
- M. All plumbing vents within a 10'-0" radius of any rooftop unit or intake louver shall be extended to a height of 3'-0" above fresh air intake.
- N. Slopes and invert elevations of all interior piping shall be established before any piping is installed in order that proper slopes will be maintained. All piping shall be located and determined where to be run to avoid conflict with other trades.
- O. Unless otherwise noted, all plumbing piping shall be routed as high as possible between bottom of roof joists and above ceiling to allow proper installation of ductwork, fire protection piping, conduits, etc.
- P. Coordinate with Architectural Drawings before roughing in plumbing.
- Q. All openings in ceilings and plenum walls for plumbing shall be sealed air tight and protected with fire stop.
- R. See site plan for extent of all piping leaving and entering building.
- S. See domestic water riser diagrams for location of valves, shock absorbers, etc.
- T. Make proper HW, CW, re-circ., waste, and vent connections to all equipment even though all branch main, elbows and connections are not shown.
- U. Cleanouts shall be provided near base of each vertical waste or solid stack. Provide 18" minimum clearance for access.
- V. Unless otherwise noted, sanitary waste piping shown is below floor and all other piping is overhead, above ceiling. Domestic hot, cold and re-circ. water piping shall be installed between ceiling and roof insulation.
- W. Unless otherwise noted, horizontal sanitary piping pitches shall be 1 percent.
- X. Unless otherwise noted, all domestic water piping and fire protection piping shall be installed on heated side of ceiling insulation.
- Y. All piping and installation shall comply with all local and national plumbing codes. Test piping as required by plumbing code and authority having jurisdiction.
- Z. For sizes of all domestic water piping see plumbing fixture schedule and domestic water riser diagrams.
- AA. For sizes of all sanitary and vent piping see plumbing fixture schedule and sanitary/vent riser diagrams.

3.2. PLUMBING SPECIALTY INSTALLATION REQUIREMENTS

- A. General: Install plumbing specialty components, connections, and devices according to manufacturer's written instructions.
- B. Install backflow preventers of type, size, and capacity indicated, at each water supply connection to mechanical equipment and systems, and to other equipment and water systems as indicated. Comply with authorities having jurisdiction. Locate backflow preventers in same room as connected equipment. Install air gap fitting on units with atmospheric vent connection and pipe relief outlet drain to nearest floor drain. Do not install bypass around backflow preventer. Label all piping downstream of backflow preventers as "non-potable" water.
- C. Field test all backflow preventers and submit test reports to Engineer. Furnish test kits as required for field testing.
- D. Install pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.
- E. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve, and where indicated.
- F. Install hose bibbs with integral or field installed vacuum breaker.
- G. Install wall hydrants with integral or field installed vacuum breaker.
- H. All hose bibbs shall be mounted 18" above finished floor, unless otherwise specified.
- I. All wall hydrants shall be mounted 24" above finished grade unless otherwise specified.
- J. Install trap seal primer valves with valve outlet piping pitched down toward drain trap a minimum of one percent and connect to floor drain body, trap, or inlet fitting. Adjust valve for proper flow. Install trap priming stations plumb and level with adequate access for servicing and maintenance.
- K. For floor drains located in toilet rooms and similar spaces where flush valves are utilized. Contractor may utilize trap primer line from flush valve tail piece.
- L. Install backwater valves in building drain piping as indicated. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing. Fasten wall hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated. For exterior installation provide handhole with hinged cover and top mounted to be flush with grade.
- M. Fasten recessed, wall mounting plumbing specialties to reinforcement built into walls.
- N. Secure supplies to supports or substrate.
- O. Install individual stop valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve as appropriate is not indicated.

- P. Install water supply stop valves in accessible locations.
- Q. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep pattern escutcheons if required to conceal protruding pipe fittings.
- R. Include wood blocking reinforcement for recessed and wall mounting plumbing specialties.
- S. Install ball valves at all shock absorbers to allow removal for service/replacement.

3.3. FITTINGS FOR FIXTURES SUPPLIED BY OTHERS

- A. Fixtures such as built in sink in counters equipment are provided under other divisions of the specifications and are complete with strainer and tailpiece. Fittings, accessories and connection of these fixtures to the plumbing system are provided under this section.
- B. Rough-in and final connection includes but is not limited to all domestic water, waste, and vent, gas systems. Furnish stops, strainers, vacuum breakers, and under counter insulation where not furnished under another Division of these specifications.

3.4. TESTING

- A. After plumbing fixtures are connected, all piping and fixtures shall be tested for operation and a smoke or peppermint test shall be made on all soil, waste and vent piping.
- B. After the building has been occupied and the various equipment is in actual use, the Contractor shall make an operating test of all equipment at a time directed by the Engineer to determine that all contract requirements are met.

3.5. CLEANING AND STERILIZATION

- A. After final testing for leaks, all potable water lines shall be thoroughly flushed, by plumbing contractor, to remove foreign material. Before placing the systems in service, sterilize the new water lines in accordance with local health department codes and at a minimum according to the following procedure:
 - 1. Through a 3/4-inch hose connection in each branch main and building main, pump in sufficient sodium hypo-chlorite to produce a free available chlorine residual of not less than 200 ppm. Plumbing Contractor shall provide plumbing connections and power for pumping chlorine into system.
 - 2. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.
 - 3. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 ppm chlorine, retain this water in the system for at least three (3) hours.
 - 4. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system. It is not necessary to retain

chlorine in any system for twenty-four hours to achieve sterilization. AWWA states that 200 ppm chlorine for three hours is sufficient.

5. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.
6. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 ppm.
7. Obtain representative water sample from the system for analysis by an independent and recognized bacteriological laboratory.
8. If the sample tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the service organization to the Contractor, certifying successful completion of the sterilization. Additionally, this report shall be forwarded to the Owner as well as be included in the O&M Manual.
9. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.
10. Take precautions to avoid use of plumbing fixtures and domestic water systems during sterilization period. Place signs on all plumbing fixtures and outlets during sterilization period.

3.6. EXAMINATION

- A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B. Verify that electric power is available and of the correct characteristics.

3.7. PREPARATION

- A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.8. INTERFACE WITH OTHER PRODUCTS

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.9. CLEANING

- A. At completion, clean plumbing equipment.

END OF SECTION

DIVISION 23 SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC
TABLE OF CONTENTS

PART 1.	GENERAL	3
1.1.	SUMMARY	3
1.2.	PERMITS AND FEES	3
1.3.	EXAMINATION OF SITE	3
1.4.	CONTRACTOR QUALIFICATION	4
1.5.	MATERIALS AND EQUIPMENT	4
1.6.	FIRE SAFE MATERIALS	5
1.7.	REFERENCED STANDARDS, CODES AND SPECIFICATIONS	5
1.8.	SUBMITTALS, REVIEW AND ACCEPTANCE	6
1.9.	SHOP DRAWINGS	7
1.10.	SUPERVISION AND COORDINATION	10
1.11.	CUTTING AND PATCHING	10
1.12.	PENETRATION OF WATERPROOF CONSTRUCTION	11
1.13.	CONCRETE AND MASONRY WORK	11
1.14.	CONNECTIONS AND ALTERATIONS TO EXISTING WORK	11
1.15.	DEMOLITION	12
1.16.	EXCAVATION AND BACKFILLING	14
1.17.	DRIVE GUARDS	14
1.18.	VIBRATION ISOLATION	14
1.19.	ALTERNATES	15
1.20.	FASTENERS/CAPS	15
1.21.	DEFINITIONS	15
1.22.	MINIMUM EFFICIENCY REQUIREMENTS	16
1.23.	SYSTEM INTEGRATION	16
PART 2.	ELECTRICAL REQUIREMENTS	16
2.1.	GENERAL MOTOR AND ELECTRICAL REQUIREMENTS	16
2.2.	MOTORS AND CONTROLS	17
2.3.	MOTOR INSTALLATION	20
2.4.	WIRING DIAGRAMS	21
2.5.	VARIABLE FREQUENCY DRIVE MOTOR BEARING PROTECTIVE RINGS:	21
2.6.	ENCLOSURES	21
PART 3.	EXECUTION	21
3.1.	EQUIPMENT INSTALLATION - COMMON REQUIREMENTS	21
3.2.	SUPPORTS, HANGERS AND FOUNDATIONS	22
3.3.	PROVISIONS FOR ACCESS	22
3.4.	PAINTING AND FINISHES	23
3.5.	CLEANING OF SYSTEMS	24
3.6.	COLOR SELECTION	24
3.7.	PROTECTION OF WORK	24
3.8.	OPERATION OF EQUIPMENT	25
3.9.	DEMONSTRATION AND TRAINING VIDEO RECORDINGS	25
3.10.	IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS	26
3.11.	WALL AND FLOOR PENETRATION	26
3.12.	RECORD DRAWINGS	27

3.13.	WARRANTY	27
3.14.	LUBRICATION	28
3.15.	OPERATIONS AND MAINTENANCE MANUALS	28
3.16.	INSTALLATION AND COORDINATION DRAWINGS	30
3.17.	PIPING SYSTEMS TESTING	30
3.18.	EQUIPMENT BY OTHERS	31
3.19.	ADDITIONAL FILTERS AND BELTS	31
3.20.	PHASING.....	31
3.21.	STRAINER CLEANING	32
3.22.	OUTAGES.....	32
	END OF SECTION.....	32

SECTION 23 05 00**COMMON WORK RESULTS FOR HVAC****PART 1. GENERAL****1.1. SUMMARY**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.
- C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.
- D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, ductwork, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.
- E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.
- F. Coordinate the work under Division 23 with the work of all other construction trades.
- G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

- A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.
- B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

- A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for contractors' failure to do so.
- B. Examine and verify specific conditions described in individual specifications sections.

- C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

- A. Any Contractor or Subcontractor performing work under Division 23 shall be fully qualified and acceptable to the Architect/Engineer and Owner. Submit the following evidence when requested:
 - 1. A list of not less than five comparable projects which the Contractor completed.
 - 2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.
 - 3. Local and/or State License, where required.
 - 4. Membership in trade or professional organizations where required.
- B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.
- C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

- A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality. Existing items of equipment are being relocated under another Division of these specifications. The Contractor shall be responsible for connecting all utilities as shown on the drawings, to equipment identified as existing.
- B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.
- C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.
- D. Substitution will not be permitted for specified items of material or equipment where noted.
- E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

- A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

- A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.
- | | | | |
|----|------------------|---|---|
| B. | AABC | | Associated Air Balance Council |
| C. | ACCA | - | Air Conditioning Contractors of America |
| D. | ASA | - | Acoustical Society of America |
| E. | ADC | | Air Diffusion Council |
| F. | AMCA | | Air Movement and Control Association |
| G. | ANSI | - | American National Standards Institute |
| H. | ARI | - | Air Conditioning and Refrigeration Institute |
| I. | ASHRAE | - | American Society of Heating, Refrigerating and Air Conditioning Engineers |
| J. | ASME | - | American Society of Mechanical Engineers |
| K. | ASPE | - | American Society of Plumbing Engineers |
| L. | ASTM | - | American Society for Testing and Materials |
| M. | DNREC | - | Delaware Department of Natural Resources |
| N. | FM | - | Factory Mutual |
| O. | IBC | - | International Building Code |
| P. | IEEE | - | Institute of Electrical and Electronics Engineers |
| Q. | MSSP
Industry | - | Manufacturers Standards Society of the Valve and Fittings |
| R. | NEC | - | National Electrical Code |
| S. | NEMA | - | National Electrical Manufacturers Association |
| T. | NFPA | - | National Fire Protection Association |
| U. | NSF | - | National Sanitation Foundation |

- V. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
- W. UL - Underwriters' Laboratories
- X. State of Delaware Fire Protection Regulations.
- Y. All mechanical equipment and materials shall comply with the codes and standards listed in the latest edition of ASHRAE HVAC Applications Handbook, Chapter entitled Codes and Standards.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

- A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.
- B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.
- C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.
- D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.
- E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.
- F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.
- G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.
- H. For any submittal requiring more than two (2) reviews by the Engineer (including those

caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

- I. For resubmissions, the Contractor must address in writing all of the Engineer's comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

- A. Prepare and submit shop drawings for all mechanical equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.
- B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.
- C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.
- D. Items and Systems
 1. Access Doors/Panels including layouts and locations
 2. Airflow Monitoring Stations
 3. Air Handling Units
 4. Air Distribution Systems
 5. Air Separators
 6. Antifreeze Fluids
 7. Antifreeze Tanks
 8. Automatic Temperature Control Systems and Equipment
 9. Automatic Glycol Feed Systems & Pressure Tanks
 10. Branch Selector Boxes/Heat Recovery Boxes
 11. Breaching and Stacks
 12. Carbon Dioxide Sensors
 13. Central Control and Monitoring Systems (CCMS) and Equipment
 14. Chemical Feed Systems

15. Condensate Pumps
16. Coordinated Drawings
17. Drip Pans
18. Differential Bypass Valves/Transmitters
19. Duct Materials
20. Energy Recovery Ventilators
21. Equipment Rails
22. Expansion Tanks and Accessories
23. Exterior Equipment/Duct Piping Supports
24. Exterior Pipe Roller Supports
25. Fans
26. Filters
27. Filter Housings
28. Fire Stopping - Methods and Materials
29. Fire Dampers
30. Flow Measuring Stations
31. Flowmeter and Primary Elements (Flow Fittings)
32. Geothermal Rooftop Heat Pumps
33. Geothermal (Condenser Water) Interior Piping
34. Glycol Feed Systems, including pressure tank
35. Grilles, Registers, Diffusers
36. Horizontal Hot Water Unit Heaters
37. Identification Systems
38. In-Line Circulators
39. Louvers
40. Material and Equipment Lists

41. Operations and Maintenance Manuals
42. Pipe Enclosures
43. Pipe Guides and Anchors
44. Pipe Materials Including Itemized Schedules
45. Preliminary Testing and Balancing Reports
46. Pressure Relief Valves
47. Pressure Regulating Valves
48. Pressure Independent Control Valves
49. Pumps
50. Refnests
51. Roof Curbs
52. Rooftop Units
53. Screen shots of ATC System Graphics
54. Static Pressure Gauges
55. Strainers
56. Tempering Valves
57. Test Certificates
58. Thermal Insulation Materials Include Table Summaries
59. Thermometers and Gauges
60. Unit Heaters
61. Variable Frequency Drive Motor Bearing Protective Rings
62. Variable Refrigerant Volume Equipment
63. Variable Speed Drives
64. Vertical In-Line Pumps
65. Vibration Isolation Materials
66. Water Treatment Services

- 67. Weatherproof Assembly Components
- 68. Wiring Diagrams, Flow Diagrams and Operating Instructions
- E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.
- F. For any shop drawing requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

1.10. SUPERVISION AND COORDINATION

- A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.
- B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, ductwork, equipment, and other work performed under Division 23.
- C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.
- D. Coordinate electrical work required under Division 23 with that under Division 26. Coordinate all work under Division 23 with work under all other Divisions.
- E. Supply services of an experienced (10 year minimum) and competent Project Manager to be in constant charge of work at site.
- F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.
- G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.
- H. Coordinate installation of large equipment requiring positioning before closing in building. Where required arrange for manufacturer to ship equipment in modules.

1.11. CUTTING AND PATCHING

- A. Accomplish all cutting and patching necessary for the installation of work under Division 23. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and work-manlike manner. Restore disturbed work to match and blend with existing construction and finish,

using materials compatible with the original. Use mechanics skilled in the particular trades required.

- B. Do not cut structural members without approval from the Architect or Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

- A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.
- B. Where pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.
- C. Furnish and install pitch pockets or weather tight curb assemblies where required.
- D. Furnish and install roof drains, curbs, vent assemblies, and duct sleeves specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer's instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these specifications.

1.13. CONCRETE AND MASONRY WORK

- A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 23. Perform work in accordance with requirements of other applicable Divisions of these specifications.
- B. Concrete shall test not less than 3,000 psi compressive strength after 28 days.
- C. Grout shall be non-shrink, high strength mortar, free of iron or chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.

1.14. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

- A. Unless otherwise noted on the drawings, where existing mechanical work is removed, pipes, valves, ductwork, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.
- B. Where work specified in Division 23 connects to existing equipment, piping, ductwork, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.
- C. Where the work specified under Division 23, or under other Divisions, requires relocation of existing equipment, piping, ductwork, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a

finished and workmanlike condition. Where existing insulation is disturbed, replace insulation where removed or damaged equal to existing, in type, thickness, density, finish and thermal resistance (R-value) value.

- D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.15. DEMOLITION

- A. Unless otherwise noted all existing equipment, piping, ductwork, etc., shall remain.
- B. Where existing equipment is indicated to be removed, all associated piping, conduit, power, controls, control panels, sensors, tubing, insulation, hangers, ductwork, supports and housekeeping pads, etc., patch, paint and repair walls/roof/floor to match existing and/or new finishes.
- C. Provide necessary piping, valves, traps, temporary feeds, drips, etc., as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time lengths of outages.
- D. The Contractor shall be responsible for visiting the site and determining the existing conditions in which the work is to be performed.
- E. Refer to phasing plans for additional requirements.
- F. Where any abandoned pipes in existing floors, walls, pipe tunnels, ceilings, etc., conflict with new work, remove abandoned pipes as necessary to accommodate new work.
- G. The location of all existing equipment, piping, ductwork, etc., indicated is approximate only and shall be checked and verified. Install all new mechanical/plumbing/fire protection work to connect to or clear existing work as applicable.
- H. Maintain egress at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and the authorities having jurisdiction.
- I. Make provisions and include in bid all costs associated with confined entry/space requirements in crawl spaces and all other applicable OSHA regulations.
- J. Where required to maintain the existing systems in operation, temporarily backfeed existing systems from new equipment. Contractor shall temporarily extend existing piping systems to new piping systems with the appropriate shut-off valves.
- K. At completion of project all temporary piping, valves, controls, etc., shall be removed in their entirety.
- L. Existing piping, equipment, ductwork, materials, etc., not required for re-use or re-installation in this project, shall be removed from the project site.
- M. Deliver to the Owner, on the premises where directed, existing equipment and materials which are removed and which are desired by the Owner or are indicated to remain the

property of the Owner.

- N. All other materials and equipment which are removed shall become property of the Contractor and shall be promptly removed, from the premises, and disposed of by the Contractor, in an approved manner. Contractor shall be responsible for proper disposal of all removed equipment containing refrigerants. Contractor shall include in his bid all cost associated with the evacuation, removal and disposal of all existing equipment containing refrigerants in accordance with EPA and Health Department requirements. Where existing split systems or ductless units are indicated to be relocated, extend refrigeration piping, power, and control wiring to the same.
- O. Where piping and/or ductwork is removed, remove all pipe or ductwork hangers which were supporting the removed piping or ductwork. Patch the remaining penetration voids with like materials and paint to match existing construction.
- P. Where required, provide and coordinate removal and re-installation of existing equipment. Take care to protect materials and equipment indicated for reuse. Contractor shall repair or replace items which are damaged. Contractor shall have Owner's representative present to confirm condition of equipment prior to demolition.
- Q. Before demolition begins, and in the presence of the Owners representative, test and note all deficiencies in all existing systems affected by demolition but not completely removed by demolition. Provide a copy of the list of system deficiencies to the Owner and the Engineer. Videotape existing conditions in each space prior to beginning demolition work.
- R. The Owner shall have the first right of refusal for all fixtures, devices and equipment removed by the Contractor.
- S. All devices and equipment designated by the Owner to remain the property of the Owner shall be moved and stored by the Contractor at a location on site as designated by the Owner. It shall be the Contractor's responsibility to store all devices and equipment in a safe manner to prevent damage while stored.
- T. All existing equipment refused by the Owner shall become the property of the Contractor and shall be removed from the site by the Contractor in a timely manner and disposed of in a legal manner.
- U. Work Abandoned in Place: Cut and remove underground pipe a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.
- V. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.
- W. Terminate services and utilities in accordance with local laws, ordinances, rules and regulations.
- X. Where hydronic system piping and equipment is removed, Contractor shall be responsible for proper disposal of all contained fluids containing glycol (ethylene or propylene), hazardous waste and water treatment chemicals. Contractor shall include in his bid all associated costs with the removal, testing, and disposal of hydronic system fluid in accordance with EPA, Health Department, and the Local Authority Having Jurisdiction.

1.16. EXCAVATION AND BACKFILLING

A. General

1. Perform all necessary excavation, or installation of work under Division 23, in whatever materials or conditions encountered, using suitable methods and equipment.
2. Accurately establish required lines and grades and properly locate the work.
3. Determine the locations of all existing utilities before commencing the work.

B. Excavation: (Refer also to other portions of the specifications)

1. Excavate only the required elevations. If excavation is carried below the foundation lines or other required limits, backfill the excess with concrete.
2. Keep banks of trenches as nearly vertical as possible, and provide sheeting and/or shoring as required for protection of work and safety of personnel. Follow local, State, OSHA, and MOSH Guidelines.
3. Keep excavations dry. Protect excavations from freezing.

C. Backfilling: (Refer also to other portions of the specifications)

1. Backfill excavations to the required elevations and restore surfaces to their original or required conditions.
2. Backfill shall be similar material, free from objectionable matter such as rubbish, roots, stumps, brush, rocks and other sharp objects. Unless otherwise indicated, suitable material from the excavation may be used for backfill.
3. Carefully place and mechanically tamp backfill in layers not exceeding 12 inches loose thickness. Compact to 95 percent minimum.
4. Do not backfill against frozen material. Do not use frozen material for backfill.

1.17. DRIVE GUARDS

- A. Provide safety guards on all exposed belt drives, motor couplings, and other rotating machinery. Provide fully enclosed guards where machinery is exposed from more than one direction.
- B. When available, guards shall be factory fabricated and furnished with the equipment. Otherwise fabricate guards of heavy gauge steel, rigidly braced, removable, and finish to match equipment served. Provide openings for tachometers. Guards shall meet local, State and O.S.H.A. requirements.

1.18. VIBRATION ISOLATION

- A. Furnish and install vibration isolators, flexible connections, supports, anchors and/or foundations required to prevent transmission of vibration from equipment, piping or

ductwork to building structure. See Division 23 Section, "Vibration Control for HVAC, Plumbing and Fire Protection Equipment".

1.19. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

1.20. FASTENERS/CAPS

- A. All fasteners located in public spaces including classrooms, corridors, lobbies, toilet rooms, etc., shall be provided with tamper proof fasteners. Provide Pin Phillips hardware as manufactured by Challenge Industries or approved equal.
- B. For all exterior grade and roof mounted equipment containing refrigerant install lockable caps on service valves to prevent tampering. Lockable caps shall be Model NPR as manufactured by Rector Seal or approved equal. Provide Model NPR Novent screwdriver tool with swiveling tip. Caps shall be suitable and specific for the refrigerant type utilized.

1.21. DEFINITIONS

- A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.
- B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.
- C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.
- D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.
- E. Ductwork includes duct material, fittings, hangers, insulation, sealant, identification and other accessories
- F. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, embedded in construction or in crawl space.
- G. Exposed means not installed underground or concealed as defined above.
- H. Invert Elevation means the elevation of the inside bottom of pipe.
- I. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceiling, unexcavated spaces, crawl spaces, and tunnels.
- J. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.
- K. ECM: Electronically Commutating Motor.

- L. Building Line: Exterior wall of building.

1.22. MINIMUM EFFICIENCY REQUIREMENTS

- A. All heating, ventilating, and air conditioning equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.
- B. All piping, ductwork, and equipment insulation shall comply with ASHRAE Standard 90.1, latest edition.
- C. All service water/heating equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.
- D. All mechanical devices, controls, accessories, and components shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

1.23. SYSTEM INTEGRATION

- A. For all HVAC equipment specified to be provided with packaged controls and interfaced with the automatic temperature control system, provide system integration between the equipment manufacturer and the automatic temperature control subcontractor.
- B. HVAC equipment submittals requiring system integration as defined above must identify all required system integration points.
- C. HVAC equipment manufacturers must coordinate with ATC subcontractor regarding system integration prior to submitting on the equipment.
- D. A system integration meeting must be arranged by the Mechanical Contractor and include, but not be limited to the systems integrator for the HVAC equipment manufacturer and the ATC Subcontractor. This portion of systems integration must occur prior to HVAC equipment being delivered to the project.
- E. Once the HVAC equipment is on site, a second systems integration meeting must be arranged by the Mechanical Contractor to coordinate the packaged controls with the ATC system. The HVAC equipment manufacturer's representative familiar with system integration and the ATC subcontractor familiar with programming must be present.
- F. A final system integrations meeting shall occur once all equipment is in place and ready for operation. The Mechanical Contractor, the HVAC equipment systems' integrator, and the ATC Subcontractor shall meet on site to jointly program, schedule, verify points, interlock devices, and fully set up all systems integration components.
- G. All systems integration coordination, programming, and graphics must be completed prior to requesting commissioning and/or inspections by the Engineer of Record.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

- A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 23 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 23. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 23.
- B. All electrical work performed under Division 23 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA and the International Building Code.
- C. Provide wiring diagrams with electrical characteristics and connection requirements.
- D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than five (5) horsepower.
- E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.
- F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.
- G. Motors located in exterior locations, wet air streams, air cooled condensers, and outdoors shall be totally enclosed weatherproof epoxy-treated type.
- H. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.
- I. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.
- J. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

2.2. MOTORS AND CONTROLS

- A. Motors and controls shall conform to the latest requirements of IEEE, NEMA, NFPA-70 and shall be UL listed. Motor sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor is advised to consult all specification sections to determine responsibility for motors and controls.
- B. Motors shall be designed, built and tested in accordance with the latest revision of NEMA

Standard MG 1.

- C. Motors used with variable-frequency controllers shall have ratings, characteristics, and features coordinated with and approved by the variable frequency controller (drive) manufacturer. As a minimum the following shall apply to variable frequency controlled motors:
1. Motors shall be manufactured to withstand peak voltages of 1600 volts with .1 microsecond rise time per NEMA MG-1.
 2. Critical vibration frequencies of motor shall not be within operating range of variable frequency controller output.
 3. Temperature rise: Match rating for Class B insulation.
 4. Insulation: Class F.
 5. Thermal Protection: Conform to MG1 requirements for thermally protected motors.
- D. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.
1. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating conditions. Under no condition shall the motor current exceed that indicated on the nameplates.
 2. Motor sizes noted in the individual equipment specifications are minimum requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overloading, exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR2 of the driven equipment to operating speed.
 3. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.
 4. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than ½ horsepower shall be single phase, and motors ½ horsepower and larger shall be 3 phase unless otherwise noted.
 5. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.
- E. Single phase motors, smaller than 1/20 horsepower shall be ball or sleeve bearing; drip-proof, totally enclosed or explosion proof, as specified; 120 volts; permanent-split capacitor or shaded pole type. These motors shall not be used for general power purposes, and shall only be provided as built-in components of such mechanical equipment as fans, unit heaters, humidifiers and damper controllers. When approved by the Engineer,

deviations from the specifications will be permitted as follows:

1. Open motors may be installed as part of an assembly where enclosure within a cabinet provides protection against moisture.
 2. Motors used in conjunction with low voltage control systems may have a voltage rating less than 115 volts.
- F. Single phase motors, greater than 1/20 horsepower and less than ½ horsepower shall be ball bearing; drip-proof, totally enclosed or explosion proof, as specified, with Class A or B insulation, as standard with the motor manufacturer; 115 or 120/208/240 volts as required; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type with minimum efficiency of 70 percent and a minimum full load power of 77 percent.
- G. Except as otherwise specified in the various specification sections, 3 phase motors 60 horsepower and smaller shall be NEMA design B squirrel cage induction type meeting the requirements of this paragraph. Motors shall be drip-proof, totally enclosed or explosion proof, as specified or indicated. Insulation shall be Class B or F, at 40 degrees C ambient temperature. Drip-proof motors shall have a 1.15 service factor and totally enclosed and explosion proof motors shall have a service factor of 1.00 or higher. Motors specified for operation at 480, 240, and 208 volts shall be nameplated 460, 230, 200 volts, respectively. Efficiencies and percent power factor at full load for three phase motors shall be not less than the values listed below for premium efficiency motors:

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
1HP and above to	85.5 percent	84 percent
1-½ HP	86.5 percent	85 percent
2HP	86.5 percent	85 percent
3HP	89.5 percent	86 percent
5HP	89.5 percent	87 percent
7½ HP	91 percent	86 percent
10HP	91.7 percent	85 percent
15HP	93.0 percent	85 percent
20HP	93.0 percent	86 percent

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
25HP	93.6 percent	85 percent
50HP and above	94.5 percent	88 percent
60 HP	95.0 percent	90 percent
75HP	95.0 percent	90 percent
100 HP	95.4 percent	90 percent
125 HP	95.8 percent	95 percent
150 HP and above	96.0 percent	95 percent

- H. Three phase motors $\frac{1}{2}$ HP or greater shall be the Duty Master XE by Reliance Electric Company, Super-E Premium Efficiency of Baldor Motor and Drives, E-plus Efficient Standard Duty Motor of the Electric Motor Division of Gould, Inc., the MAC II High Efficiency motor of Westinghouse Electric Corp., the equivalent product of General Electric, or approved equal.
- I. For motors serving equipment being controlled by a variable speed drive, motor shall be premium efficiency inverter duty rated.
- J. Motor frames shall be NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast-iron or aluminum with steel inserts.
- K. Control of each motor shall be manual or automatic as specified for each in the various mechanical sections. In general, and unless otherwise specified for a particular item in the various mechanical sections of the specifications, motor starters and controls shall be specified and provided under the various electrical sections of these specifications.
- L. Provide manufacturer's warranty for all motors for minimum of 5 years including all labor and materials.

2.3. MOTOR INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors to support shaft regardless of shaft position.
- C. Check line voltage and phase and ensure agreement with nameplate. Check that proper thermal overloads have been installed prior to operating motors.

- D. Use adjustable motor mounting bases for belt-driven motors.
- E. Align pulleys and install belts.
- F. Tension belts according to manufacturer's written instructions.

2.4. WIRING DIAGRAMS

- A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.
- B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.
- C. Provide wiring diagrams for all major mechanical items of equipment to electrical contractor and ATC subcontractor for coordination.

2.5. VARIABLE FREQUENCY DRIVE MOTOR BEARING PROTECTIVE RINGS:

- A. For all motors driven by a variable frequency PWM drive include a maintenance free, circumferential, conductive micro fiber shaft grounding ring to discharge shaft currents. Grounding rings shall be manufactured by AEGIS SGR or approved equal.
- B. Furnish units with one year warranty.
- C. Size and select Bearing Protective Rings per the manufacturer requirements based on the motor size, shaft diameter, and shaft shoulder length. For motors with slingers furnish and install NEMA /IEC kit as required.
- D. Furnish and apply Colloidal silver shaft coating to all shafts with Bearing Protective Rings to improve shaft voltage discharge capability.

2.6. ENCLOSURES

- A. Electrical enclosures including factory provided enclosures, field provided and installed enclosures, and automatic temperature control system enclosures shall be as follows:
 - 1. Dry Interior Locations: NEMA 1.
 - 2. Damp/Wet Locations, Including Exterior Locations: NEMA 3R.
 - 3. Corrosive Locations, Including Indoor Pools, Laboratories, Chemical Storage Rooms and Similar Space: NEMA 4X.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.
- B. Install equipment according to approved submittal data. Portions of the work are shown

only in diagrammatic form. Refer conflicts to Architect.

- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- E. Install equipment giving right of way to piping installed at required slope.
- F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.
- G. Do not install equipment, ductwork, or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment, ductwork, and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

- A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workman-like manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.
- B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.
- C. Concrete housekeeping pads and foundations shall be not less than 4 inches high (6 inches for high for boilers) and shall extend a minimum of 6 inches beyond equipment bases. Provide wire-mesh reinforcement; chamfer exposed edges and corners; and finish exposed surfaces smooth.

3.3. PROVISIONS FOR ACCESS

- A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, dampers, filters, controls, control devices, cleanouts, fire dampers, damper operators, traps, and other devices requiring maintenance, service, adjustment, balancing or manual operation.
- B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 24 inches x 24 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Mark each access door within finished spaces with a small color coded and numbered tab. Provide a chart or index for identification. Provide U.L. approved and

labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.

1. Acoustical or Cement Plaster: Style B
 2. Hard Finish Plaster: Style K or L
 - i. Masonry or Dry Wall: Style M
- C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.
- D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish. Label inside of access door as to what it serves.
- E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.
- F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, natatoriums, kitchens, dishwasher rooms, can wash rooms, and similar spaces, etc...) provide aluminum access doors/frames.

3.4. PAINTING AND FINISHES

- A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.
- B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.
- C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.
- D. Protect all finishes and restore any finishes damaged as a result of work under Division 23 to their original condition.
- E. The preceding requirements apply to all work, whether exposed or concealed.
- F. Remove all construction marking and writing from exposed equipment, ductwork, piping and building surfaces. Do not paint manufacturer's labels or tags.
- G. All exposed ductwork, piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.
- H. All exterior roof mounted ductwork, equipment, piping, breeching, and vents shall be

painted to match roof in color as selected by Architect.

- I. All exposed ductwork, piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.
- J. All exposed ductwork, piping, equipment, etc., in Mechanical Rooms, Boiler Rooms, Geothermal Pump Rooms, Penthouses, Fire Pump Rooms, Mezzanines, and Storage where PVC jacketed shall not require painting. Label and identify and color code as specified.

3.5. CLEANING OF SYSTEMS

- A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.
- B. Flush piping in re-circulating water systems to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating name of service company used.
- C. Maintain strainers and dirt pockets in clean condition.
- D. Clean fans, ductwork, enclosures, flues, registers, grilles, and diffusers at completion of work.
- E. Install filters of equal efficiency to those specified in permanent air systems operated for temporary heating during construction. Replace with clean filters as specified prior to acceptance and after cleaning of system.
- F. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.
- G. Leave systems clean, and in complete running order.
- H. All HVAC piping/equipment strainers must be pulled and cleaned prior to substantial completion. In addition six (6) months after substantial completion all HVAC piping/equipment strainers must be pulled and cleaned a second time. Document and submit verification of strainer cleaning to Engineer, Owner, and Construction Manager.

3.6. COLOR SELECTION

- A. Color of finishes shall be as selected by the Architect.
- B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.7. PROTECTION OF WORK

- A. Protect work, material and equipment from weather and construction operations before and

after installation. Properly store and handle all materials and equipment.

- B. Cover temporary openings in piping, ductwork, and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.
- C. Cover or otherwise protect all finishes.
- D. Replace damaged materials, devices, finishes and equipment.
- E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.
- F. Provide moisture protection for ductwork in areas which are not under roof.

3.8. OPERATION OF EQUIPMENT

- A. Clean all systems and equipment prior to initial operation for testing, balancing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.
- B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.
- C. Submit factory start-up sheets or field start-ups sheets for all equipment prior to the commencement of testing and balancing work. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.
- D. Do not use mechanical systems for temporary services or temporary conditioning during construction, unless approved by Owner in writing. Refer to Division 01 Section "Temporary Facilities and Controls" for temporary heating/cooling during construction.
- E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.9. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

- A. General: Record demonstration and training video recordings. Record each training module separately.
 - 1. At beginning of each training module, record each chart containing learning objective and lesson outline.
- B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer
- C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

- D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.
- E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

- A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.
- B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as "Normally Open" or "Normally Closed" as required.
- C. All items of equipment, including motor starters, disconnects and ATC panels shall be furnished with white on black plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal).
- D. Provide six (6) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Record and Information Booklet as hereinafter specified.
- E. All lines piping and ductwork installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and ductwork and service. Refer to Division 23 Section, "HVAC Piping, Fittings, Valves, Etc." and Division 23 Section, "HVAC Air Distribution". Color-code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.
- F. Submit list of wording, symbols, letter size, and color coding for mechanical identification. Submit samples of equipment identification cards, piping labels, ductwork labels, and valve tags to Engineer for review prior to installation.
- G. Provide at least 16 hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner. Additional instruction time for the automatic temperature control (ATC) system is specified in Division 23 Section, "Instrumentation & Controls of HVAC & Plumbing Systems".
- H. Contractor shall demonstrate Sequences of Operation of all equipment in presence of Owner's representative, Engineer, and ATC subcontractor.

3.11. WALL AND FLOOR PENETRATION

- A. All penetrations of partitions, ceilings, roofs and floors by ducts, piping or conduit under Division 23 shall be sleeved, sealed, and caulked airtight for sound and air transfer control.

Penetrations of mechanical room partitions, ceilings, and floors shall be as specified in Division 23 Section, "Vibration Control for HVAC, Plumbing and Fire Protection Equipment".

- B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC & Plumbing Penetration Firestopping".
- C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.
- D. Provide pipe escutcheons and duct flanges for sleeved pipes and ducts in finished areas.
- E. Piping sleeves:
 - 1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.
 - 2. Twenty-two (22) gauge galvanized steel elsewhere.
- F. Ductwork sleeves: 20 gauge galvanized steel.
- G. Extend all floor sleeves through floor at least 3/4-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.
- H. Sleeves for penetrations in kitchen and food service areas shall finish .375 inches above floor or flush with wall surfaces and be neatly pointed up to fit snugly against floor or wall material.

3.12. RECORD DRAWINGS

- A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the mechanical contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.
- B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

- A. Contractor's attention is directed to warranty obligations contained in the GENERAL CONDITIONS.
- B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer's warranties shall be included in the operations and maintenance manuals.
- C. The Contractor guarantees for a two year period from the time of final acceptance by the

Owner.

1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.
2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.
3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section. Contractor shall repair and/or replace any/all damage to finishes and furniture resulting from their corrective work.
4. That the entire work shall be water-tight and leak-proof.

3.14. LUBRICATION

- A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Record and Information Booklet.
- B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

3.15. OPERATIONS AND MAINTENANCE MANUALS

- A. The Contractor shall have prepared three (3) hardcopies and one (1) electronic copy of the Operations and Maintenance Manuals and deliver these copies of the booklet to the Owner. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped.
- B. The booklet shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manuals – Cape Henlopen High School Additions and Renovations - HVAC. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.
- C. Provide the following data in the booklet:
 1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.
 2. Maintenance operation and lubrication instructions on each piece of equipment furnished.

3. Complete catalog data on each piece of heating and air conditioning equipment furnished including approved shop drawing.
 4. Manufacturer's extended limited warranties on equipment including but not limited to boiler breeching, variable frequency drives, air conditioning compressors, buffer tanks, heat pumps, and VRV Equipment.
 5. Chart form indicating frequency and type of routine maintenance for all mechanical equipment. The chart shall also indicate model number of equipment, location and service.
 6. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.
 7. Provide supplier and subcontractor's names, address, and phone number.
 8. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.
 9. Provide and install in locations as directed by the Owner, valve charts including valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass.
 10. Copy of the approved balancing report including duct leakage data.
 11. ATC systems including as-built ATC drawings of systems including internal of all panels.
 12. Access panel charts with index illustrating the location and purpose of access panels.
 13. Approved Boiler Inspector, and Electrical Certificates.
 14. Start-up reports for equipment.
 15. Water treatment test reports.
 16. Provide and install in locations as directed by Owner, filter charts, including filter type, size, model number, manufacturer, quantity and size for each filter utilized on the project. Filter charts shall be enclosed in a durable polymer based frame with a cover safety glass.
 17. Insert color graphic with embedded parameters for ATC system into record and information booklet.
 18. Filter charts indicating equipment served, size, and type of filter required.
 19. Documentation of strainer pulling and cleaning.
- D. Submit Record and Information Booklets prior to anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Record and

Information booklets be reviewed and approved.

3.16. INSTALLATION AND COORDINATION DRAWINGS

- A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following:
 - 1. Complete Ductwork, Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.
- B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment, piping and ductwork in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.
- C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.
- D. Refer to Division 01 Section "Project Management and Coordination" for additional requirements related to coordination drawings.

3.17. PIPING SYSTEMS TESTING

- A. The entire new HVAC piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of four (4) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	TEST PRESSURE
Condenser Water Supply & Return Piping Including Chemical Treatment Piping	100 psi
Heating, Water Supply & Return Piping, Including Chemical Treatment Piping	100 psi
Geothermal (Condenser Water) Interior Heat Pump Piping, Including Chemical Treatment Piping	100 psi
Refrigerant Piping	550 psig with Nitrogen

- B. Ductwork pressure testing shall be as specified in another division of these specifications.
- C. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.
- D. Refrigerant piping shall be tested utilizing nitrogen per equipment manufacturer's requirements.
- E. All testing shall be witnessed by Construction Manager.

3.18. EQUIPMENT BY OTHERS

- A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions or furnished by the Owner. Connections shall be complete in all respects to render this equipment functional to its fullest intent.
- B. It shall be the responsibility of the supplier of this equipment to furnish complete instructions for connections. Failure to do so will not relieve this contractor of any responsibility for improper equipment operation.

3.19. ADDITIONAL FILTERS AND BELTS

- A. One complete set of additional filters and belts shall be turned over to the owner upon final acceptance of the building by the owner. Provide correspondence to the Engineer (copy) documenting that additional filters and belts have been turned over to Owner.
- B. All filters and belts shall be tagged and identified for equipment served. Furnish filters in protection wrap.

3.20. PHASING

- A. Refer to Architectural Specifications and contract drawings for any required phasing.
- B. Maintain building egress and traffic ways at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and Authorities having jurisdiction.
- C. Provide dust barriers/partitions, penetration closures, etc, to ensure safety of building occupants and protection of existing surroundings.
- D. The Building shall remain watertight at all times.
- E. Refer to phasing plans for additional requirements.
- F. Provide necessary piping, valves, steam traps, drips, piping, conduit, controllers, ATC wiring, etc. as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time length of outages. Provide steam traps, drips, valves, etc., to maintain existing steam system in operation until all equipment is connected to the hot water system. Temporarily feed new systems with existing system where required or shown on contract drawings.
- G. At completion of the first phase the ATC System shall be sufficiently complete to turn over HVAC equipment. All wiring, testing, balancing, commissioning, programming, graphics, and ATC computer shall be completed and operational for all equipment in each phase prior to Owner taking ownership of the same.
- H. Within thirty days of Award of Contract, the Contractor shall submit a minimum of six (6) copies of the proposed Phasing Plan (Drawings and detailed written description) to the Architect for review and approval based on the general and specific requirements indicated on the Drawings and Specifications. The phasing plan shall reflect the work of all trades. The phasing plan shall be updated as often as needed (i.e. major deviations and/or modified sequence of events) and reviewed during each progress meeting so the facility and

Architect can be aware of the areas of construction and progress as it relates to the approved schedule.

- I. Due to phased construction, some systems must be operated at part load conditions until later phases are completed. Contractor must carefully operate all variable speed pumps and variable speed fans so as not to operate below minimum speeds as required by pump/fan manufacturer.
- J. While work is in progress, except for designated short intervals during which connections are made, continuity of service shall be maintained to all existing systems. Interruptions shall be coordinated with the Owner as to time and duration. The contractor shall be responsible for any interruptions to service and shall repair any damages to existing systems caused by his operations.

3.21. STRAINER CLEANING

- A. All equipment strainers must be pulled and cleaned at substantial completion. Document in writing and via digital photographs that all strainers have been pulled and cleaned.
- B. One year after project substantial completion all strainers shall be pulled again and cleaned. Document in writing and via digital photographs that all strainers were pulled and clean at the one year after project substantial completion data.
- C. Insert documentation that the strainers have been pulled and cleaned in the Record and Information Books.
- D. Re-purge hydronic systems of all air after strainers are pulled and cleaned.

3.22. OUTAGES

- A. Provide a minimum of fourteen (14) days notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.
- B. Submit Outage Request form, attached at end of this Section, to Owner for approval.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: _____ BY: _____

DATE FOR OUTAGE: _____ FIRM: _____

START OUTAGE-TIME: _____ DATE: _____

END OUTAGE -- TIME: _____ DATE: _____

AREAS AND ROOMS: _____

FLOOR(S): _____

AREA(S): _____

ROOM(S): _____

WORK TO BE PERFORMED: _____

SYSTEM(S): _____

REQUEST APPROVED BY: _____

(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: _____

YES ____ NO ____ BY: _____ DATE: _____

DATE/TIME-AS REQUESTED: _____ OTHER : _____

OWNER'S PRESENCE REQUIRED: _____

YES: ____ NO: ____ NAME: _____

POINT OF CONTACT: _____ PHONE: _____

DIVISION 23 SECTION 23 05 05
HVAC PIPING, FITTINGS & VALVES
TABLE OF CONTENTS

PART 1. GENERAL.....	2
1.1. SUMMARY.....	2
1.2. SYSTEM DESCRIPTION CONDITIONS.....	2
1.3. QUALITY ASSURANCE.....	2
1.4. DELIVERY, STORAGE AND HANDLING.....	3
1.5. ENVIRONMENTAL REQUIREMENTS.....	3
1.6. EXTRA MATERIALS.....	3
1.7. ALTERNATES.....	3
PART 2. PRODUCTS.....	3
2.1. PIPE MATERIALS.....	3
2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES.....	10
2.3. HYDRONIC EXPANSION LOOPS.....	13
2.4. VALVES.....	13
2.5. STRAINERS.....	14
2.6. UNIONS, FLANGES, AND COUPLINGS.....	15
2.7. MANUAL AIR VENTS.....	15
2.8. AUTOMATIC AIR VENTS.....	15
2.9. THERMOMETERS.....	15
2.10. PRESSURE GAUGES.....	16
2.11. FLOW METERS.....	16
2.12. PIPING SPECIALTIES.....	16
2.13. ESCUTCHEONS.....	17
2.14. DIELECTRIC CONNECTIONS:.....	17
2.15. SLEEVES.....	17
2.16. PRESSURE REDUCING VALVES.....	18
2.17. WATER PROOF PIPE PENETRATION SEALS.....	18
2.18. TEST PLUGS.....	18
2.19. FLO-CONTROL VALVES.....	19
2.20. TRANSITION FITTINGS.....	19
PART 3. EXECUTION.....	20
3.1. GENERAL PIPING INSTALLATION REQUIREMENTS.....	20
3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.....	22
3.3. VALVE INSTALLATION REQUIREMENTS.....	22
3.4. REFRIGERANT PIPING AND ACCESSORIES INSTALLATION REQUIREMENTS.....	23
3.5. PIPE JOINTS INSTALLATION REQUIREMENTS.....	28
3.6. HANGERS, SUPPORTS, ANCHORS, GUIDES INSTALLATION REQUIREMENTS.....	29
3.7. AIR VENTING INSTALLATION REQUIREMENTS.....	30
3.8. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS.....	30
3.9. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS.....	31
3.10. VALVE IDENTIFICATION REQUIREMENTS.....	32
3.11. CLEANING PIPING AND EQUIPMENT.....	32
3.12. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS.....	32

SECTION 23 05 05

HVAC PIPING, FITTINGS AND VALVES

PART 1. GENERAL

1.1. SUMMARY

- A. The conditions of the contract and other general requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC and Division 01, General Requirements.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2. SYSTEM DESCRIPTION CONDITIONS

- A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings. Final connections to equipment furnished in other sections of the specifications shall be included under this section.
- B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and International Building Code (IBC).
- C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.
- F. Provide pipe hangers and supports in accordance with ASTM B31.9 and MSS SP69 unless indicated otherwise.
- G. Use spring loaded "silent" check valves on discharge of all pumps.
- H. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.
- I. At all runout piping serving equipment, use swing joints with elbows to prevent excessive movement of piping due to expansion.

1.3. QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.

- B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulation. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.
- C. Welders Certification: In accordance with ASME Section 9.
- D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - 1. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.
- E. Maintain one copy of each document on site.

1.4. DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect and handle products to site under as hereinbefore specified.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

- A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

- A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

- A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.
 - 1. Heating Water Supply & Return Piping, Chemical Treatment Piping (Inside of Building):

- a. Pipe: Schedule 40 Black steel pipe, ASTM A53
1-1/2 inch and smaller - Type F, ASTM A53 steel (CW) with threaded joints
2 inch and larger - Grade B, Type E, ASTM A53 steel (ERW) with welded, flanged or grooved joints.
- b. Fittings & Joints: 2-1/2 inches & larger, schedule 40 wrought steel ASTM A234 Grade WPB or Std. B16.9 long radius welding; factory-fabricated from ASTM A53 pipe; or ASTM A536 ductile iron; 2 inches & smaller 125 lb. std. cast iron screwed, ASTM Standard B16.4; or Vic-Press precision, cold drawn, stainless steel with elastomer O-ring seals. Joints shall be threaded or AWS D1.1 welded. Victaulic, Apollo/Shurjoint, or approved equal grooved joints shall be acceptable.
- c. Flanges: Wrought steel Class 150 welding neck. ASTM Standard B16.5.
- d. Grooved Joint Couplings: Two ductile iron housings, pressure responsive elastomer gasket, and ASTM A449 zinc electroplated steel bolts and nuts. Couplings shall comply with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
 - i. Rigid Type: Coupling housings shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with ANSI B31.1 and B31.9.
 - 1) Victaulic Style 107H, Apollo/Shurjoint Z-07, Installation-Ready or approved equal, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 degrees F.
 - ii. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Victaulic Installation-Ready Style 177 or Style 77, or approved equal.
 - iii. 14" and Larger: AGS Series, two segment coupling with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W07 (rigid) and Style W77 (flexible), Apollo/Shurjoint 7707/7707N, or approved equal.
 - iv. Flange adapters shall be suitable for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741/W741, Apollo/Shurjoint 7041, or approved equal.
 - v. Rolled form grooves only. Cut grooves are prohibited.
 - vi. Verify gasket compatibility on Chemical Treatment piping.
- e. Gate Valves: 2-1/2 inches & larger - IBBM, 150 lb. OS&Y grooved end or flanged; 2 inches & smaller - 150 lb. Bronze body bronze trim. Basis of Design: Victaulic Series 771V or approved equal.
For valves 4 inch and larger located in mechanical equipment spaces 10 feet-0 inch or greater above finished floor, valve shall have chain wheel operators with chains extending to within 6 feet-0 inch above finished floor. Chain wheels and guides shall be galvanized.
- f. Ball Valves: Shut-off valves 2 inches and smaller shall be ball valves. Ball valves shall be 600cwp, 150swp full port, with RPTFE seats, chrome plated ball and stem 2 1/2 and larger, class 125 cast iron OS&Y IBBM gate valve, brass or bronze body, standard port, 2 piece body. Ball valves shall be VicPress end, threaded end or solder end as required to accommodate piping. Ball valves shall be as manufactured by Victaulic, Crane, Apollo,

- Nibco, Watts or engineer approved equal.
- g. Globe Valves: 2-1/2 inches & larger – IBBM 125 lb.std. flanged, with No. 1 disc; 2 inches & smaller - bronze 150 lb. std. screw ends, with #1 disc.
 - h. Check Valves: 2-1/2 inches & larger – IBBM or stainless steel trim, 125 lb.std. grooved end or flanged spring-assisted swing check suitable for vertical or horizontal installation, with metal disc; 2 inch & smaller - 125 lb. std. screwed. Provide "silent" spring loaded check valves at all pump discharges. Victaulic Series 716/W715 or approved equal.
 - i. Balancing Valves: Victaulic Series 377/365, DeZurik Series 100, Fig. 118 or approved equal, ductile iron or cast iron construction, stainless steel bearings, nickel seats (3 inches and larger) non-lubricated, eccentric plug with EPDM, chlorobutyl rubber or Bunz-N resilient faced plugs suitable for 230 degrees F, semi-steel screwed with fig. 159, removable lever and open. nut for valves 3 inches and smaller. For valves 4-inch and larger, provide gear operators and grooved ends or flanged connections. Provide chain operated valves for sizes 4-inches and larger located 10 feet-0 inches or more above finished floor. Chains shall extend to within 6 inch-0 inches above finished floor. All valves shall have adjustable memory stop. Chain wheel and guide shall be galvanized.
 - j. Butterfly Valves: Victaulic Vic300 MasterSeal/ AGS-Vic300, DeZurik, Apollo 215L series, high performance or Keystone K-Loc, type with infinite position lever (for 3-inches and smaller) and pressure-responsive seat or double seat type and memory stop. Provide gear operator on valves 4-inches and larger.
 - i. Valve stem shall be stainless steel, and shall be offset from the disc centerline to provide complete 360 degree circumferential seating.
 - ii. Valve shall be rated to +250 deg F in sizes through 12-inches.
 - iii. Seat shall be elastomer, of a grade suitable for the intended service. The seat shall be pressure responsive in sizes through 12 inches.
 - iv. For valves 4 inches and larger located 10 feet-0 inches or more above finished floor shall be provided with chain operators with chains extending to within 6 feet-0 inches above finished floor. Chain wheel and guide shall be galvanized.
 - k. Combination Shut-off/Balancing Valves:
Victaulic/ TA Hydronics, Taco Circuit Setter, Bell & Gossett Circuit Setter Plus, Flowset Accuset, Gerand, or as approved equal, 2-inch-3-inch 300 lb. rated Ametal (copper-alloy) body globe type or ball valve with bronze body/brass ball construction with glass and carbon filled TFE seats, in-line flow meter and balancing and shut-off valve with built in ball valve for flow adjustment. Valve shall have memory stop, calibrated nameplate, Schrader valve connections and preformed molded insulation. Valves shall be leaktight at full rated working pressure. Balance valve size shall be selected based on manufacturer's acceptable flow range and design flow rate. Pressure drop through combination shut off balance valves shall not exceed 5 feet of head at design flow rate.
Coil-Hook-up Connections: Victaulic Koil-Kits Series 799 or 79V or approved equal may be used at coil connections. The kit shall include a autoflow balancing valve, Series 78Y Strainer-Ball, Series 78U Union-

- Port fitting, with Series 78T ball valve and required coil hoses. A Style 793 and/or 794 differential pressure controller shall be provided as required.
- l. Extended Valve Stems: Provide and install round collar type extended valve stems on all valves installed in insulated piping. Valve stem and collar shall be selected to suit insulation thickness and maintain valve handles outside of insulation.
 - m. Alternate:
 - i. At contractors option all HVAC water supply and return lines may be copper type L (ASTM Std. B88) with wrought copper fittings (ASTM Std. B 16.22) with brazed or 95-5 silver solder joints lead and antimony based solders are prohibited and all bronze valves may be used on piping 2 inches and less in size.
 - ii. At Contractors option, Viega Pro Press/ Mega Press, or Apollo Press/Apollo Power Press, Pressure Seal mechanical fittings may be utilized. Viega, ProPress Pressure Seal Fittings: Bronze or copper shall conform to ASME B16.51, ICC LC 1002, and IAPMO PS 117. ProPress fittings ½-inch thru 4- inch for use with ASTM B88 copper tube type L and ½-inch up to 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element and Smart Connect (SC) feature. 2-1/2-inch thru 4-inch shall have a 420 stainless steel grip ring, PBT separator ring, EPDM sealing element and Smart Connect (SC) feature.
2. Interior Geothermal (Condenser Water) Water Source Heat Pump Supply & Return Piping:
- a. Pipe: Schedule 40 Black steel pipe, ASTM A53 1-1/2 inch and smaller - Type F, ASTM A53 steel (CW) with threaded joints. 2 inch and larger - Grade B, Type E, ASTM A53 steel (ERW) with welded, flanged or grooved joints.
 - b. Fittings & Joints: 2-1/2 inches & larger, schedule 40 wrought steel ASTM A234 Grade WPB or Std. B16.9 long radius welding; factory-fabricated from ASTM A53 pipe; or ASTM A536 ductile iron 2-inches & smaller 125 lb. std. cast iron screwed, ASTM Standard B16.4; or Vic-Press precision, cold drawn, stainless steel with elastomer O-ring seals. Joints shall be threaded or AWS D1.1 welded. Victaulic, Apollo/Shurjoint, or approved equal grooved joints shall also be acceptable.
 - c. Flanges: Wrought steel Class 150 welding neck. ASTM Standard B16.5.
 - d. Grooved: Joint Couplings: Two ductile iron housings, pressure responsive elastomer gasket, and ASTM A449 zinc electroplated steel bolts and nuts. Couplings shall comply with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
 - i. Rigid Type: Coupling housings shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with ANSI B31.1 and B31.9.
 - 1) Victaulic Style 107H, Installation-Ready, Apollo/Shurjoint Z-07N, or approved equal, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 deg F.

- ii. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Victaulic Installation-Ready Style 177 or Style 77, Apollo/Shurjoint, or approved equal.
- iii. 14" and Larger: AGS Series, two segment coupling with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W07 (rigid) and Style W77 (flexible), Apollo/Shurjoint 7707N, or approved equal.
- iv. Flange adapters shall be suitable for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741/W741, Apollo/Shurjoint 65FH, or approved equal.
- v. Ductile iron. Rolled form grooves only. Cut grooves are prohibited.
- vi. Verify gasket compatibility on Chemical Treatment piping.
- e. Gate Valves: 4 inches & larger - IBBM, 150 lb. OS&Y grooved end or flanged; 2 inch & smaller - 150 lb. Bronze body bronze trim. Victaulic Series 771V or approved equal.
For valves 4 inch and larger located in mechanical equipment spaces 10'-0-inches or greater above finished floor, valve shall have chain wheel operators with chains extending to within 6 feet –0 inches above finished floor. Chain wheels and guides shall be galvanized.
- f. Ball Valves: Shut-off valves 3 inch and smaller shall be ball valves. Ball valves shall be 150 lbs, brass or bronze body, standard port, 2 piece body, TFE seats with bronze trim. Ball valves shall be Vic-Press end, threaded end or solder end as required to accommodate piping. Ball valves shall be as manufactured by Victaulic, Crane, Apollo, Nibco, Watts or engineer approved equal.
- g. Globe Valves: 2-1/2 inches & larger - IBBM, 125 lb.std. flanged, with No. 1 disc; 2 inch & smaller - bronze 150 lb.std. screw ends, with #1 disc.
- h. Check Valves: 2-1/2 inches & larger – IBBM or stainless steel trim, 125 lb.std. grooved end or flanged spring-assisted swing check suitable for vertical or horizontal installation, with metal disc; 2 inch & smaller - 125 lb. std. screwed. Provide "silent" spring loaded check valves at all pump discharges. Victaulic Series 716/W715, Apollo/Shurjoint 67CVE/CVN, or approved equal.
- i. Balancing Valves: Victaulic Series 377/365, DeZurik Series 100, Fig. 118, Milliken, or engineer approved equal, ductile iron or cast iron construction, stainless steel bearings, nickel seats (3 inches and larger) non-lubricated, eccentric plug with EPDM or chlorobutyl rubber or Bunz-N resilient faced plugs suitable for 230 degrees Fahrenheit, semi-steel screwed with fig. 159, removable lever and open. nut for valves 3 inches and smaller. For valves 4 inches and larger, provide gear operators and grooved ends or flanged connections. All valves shall have adjustable memory stop. Do not install balance valves on the discharge of variable speed pumps.
- j. Butterfly Valves: Victaulic Vic300 MasterSeal/ AGS – Vic300, DeZurik, Apollo/Shurjoint SJ-300-N, high performance or Keystone K-Loc, type with infinite position lever (for 4 inches and larger) and pressure responsive seat or double seat type and memory stop. Provide gear operator on valves 4-inches and larger. For valves 4 inches and larger located 10 feet –0 inch or more above finished floor shall be provided with

chain operators with chains extending to within 6'-0-inches above finished floor. Chain wheel and guide shall be galvanized.

- i. Valve stem shall be stainless steel, and shall be offset from the disc centerline to provide complete 360 degree circumferential seating.
 - ii. Valve shall be rated to +250 deg F in sizes through 12 inches.
 - iii. Seat shall be elastomer, of a grade suitable for the intended service. The seat shall be pressure responsive in sizes through 12 inches.
- k. Combination Shut-off/Balancing Valves:
Victaulic/ TA Hydronics, Taco Circuit Setter, Bell & Gossett Circuit Setter Plus, Flowset Accuset, Gerand, or as approved equal, 2 inches- 3 inches 300 lb. rated Ametal (copper-alloy) body globe type or ball valve with bronze body/brass ball construction with glass and carbon filled TFE seats, in-line flow meter and balancing and shut-off valve with built in ball valve for flow adjustment. Valve shall have memory stop, calibrated nameplate, Schrader valve connections and preformed molded insulation. Valves shall be leaktight at full rated working pressure. Balance valve size shall be selected based on manufacturer's acceptable flow range and design flow rate. Pressure drop through combination shut off balance valves shall not exceed 5 feet of head at design flow rate.
- l. Extended Valve Stems: Provide and install round collar type extended valve stems on all valves installed in insulated piping. Valve stem and collar shall be selected to suit insulation thickness and maintain valve handles outside of insulation.
- m. Alternate:
- i. At contractors option, all interior condenser water source heat pump supply and return lines may be copper type L (ASTM Std. B88) with wrought copper fittings (ASTM Std. B 16.22) with brazed or 95-5 silver solder joints lead and antimony based solders are prohibited and all bronze valves may be used on piping 2-inches and less in size.
 - ii. At Contractors option, Pro Press with mechanical fittings may be utilized. Viega, Apollo Press/Apollo Power Press, ProPress Pressure Seal Fittings: Bronze or copper shall conform to ASME B16.51, ICC LC 1002, and IAPMO PS 117. ProPress fittings ½-inch thru 4-inch for use with ASTM B88 copper tube type L and ½-inch up to 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element and Smart Connect (SC) feature. 2-1/2-inch thru 4-inch shall have a 420 stainless steel grip ring, PBT separator ring, EPDM sealing element and Smart Connect (SC) feature.
 - iii. At the Contractor's option, interior condenser water piping may be Isco, Aquatherm, NiRon, or Pestan polypropylene pipe and fittings. Pipe shall contain a fiber layer (faser) to restrict thermal expansion. Furnish pipe with factory applied UV resistant coating. All joints shall be fusion welded per manufacturer's requirements. Install expansion loops as required by the manufacturer. Where installed in plenums install fire resistant wrap on all piping to comply with NFPA.

3. Refrigeration Piping:

- a. Concealed: Tube Size $\frac{3}{4}$ -inch & Smaller:
ASTM B280, copper tube; Type ACR, soft annealed temper fittings; cast copper-alloy fittings for flared copper tubes; flared joints. Fittings shall be ASME B16.22, wrought copper. Joints shall be brazed, AWS A5.8, BCUP silver/phosphorous/copper alloy with melting range 1190 to 1480 degrees F.
- b. Concealed: Tube Size $\frac{7}{8}$ inch through 4-1/8inches:
Copper tube, Type ACR, soft annealed temper; wrought-copper, brazed-joint fittings; brazed joints.
- c. Exposed: Tube Size $\frac{3}{4}$ Inch and Smaller:
Copper pipe, Type ASTM B88, Type K with brazed wrought-copper fittings conforming to ASME B16.22. Filler metal shall be brazing type conform to AWS A5.8.
- d. Exposed: Tube Sizes $\frac{7}{8}$ Inch and Larger:
Copper pipe, Type ASTM B88, Type K with brazed wrought-copper fittings conforming to ASME B16.22. Filler metal shall be brazing type conforming to AWS A5.8.
- e. Braze Joints: Braze joints using American Welding Society (AWS) classification BCuP-4 for brazing filler metal.
- f. Flexible connectors: 500-psig (3450-kPa) minimum operating pressure; stainless-steel core and high-tensile stainless-steel-braid covering; dehydrated, pressure tested, minimum 7 inches (180 mm) long.
- g. Diaphragm Packless Valves:
500-psig (3450-kPa) working pressure and 275 degrees Fahrenheit (135 degrees C) working temperature; globe design with straight-through or angle pattern; forged-brass or bronze body and bonnet, phosphor bronze and stainless-steel diaphragms, rising stem and handwheel, stainless-steel spring, nylon seat disc, and with solder-end connections.
- h. Packed-Angle Valves: 500-psig (3450-kPa) working pressure and 275 degrees Fahrenheit (135 degrees C) working temperature; forged-brass or bronze body, forged-brass seal caps with copper gasket, back seating, rising stem and seat, molded stem packing, and with solder-end connections.
- i. Check Valves: Smaller than NPS 1 (DN 25): 400-psig (2760-kPa) operating pressure and 285 degrees Fahrenheit (141 deg Celsius) operating temperature; cast-brass body, with removable piston, polytetrafluoroethylene seat, and stainless-steel spring; globe design. Valve shall be straight-through pattern, with brazed-end connections.
- j. Check Valves: NPS 1 (DN 25) and Larger: 400-psig (2760-kPa) operating pressure and 285 degrees Fahrenheit (141 deg Celsius) operating temperature; cast-bronze body, with cast-bronze or forged-brass bolted bonnet; floating piston with mechanically retained polytetrafluoroethylene seat disc. Valve shall be straight-through or angle pattern, with solder-end connections.
- k. Service Valves: 500-psig (3450-kPa) pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with brazed-end connections.
- l. Service valves for VRV branch selector boxes and indoor heat pumps shall be bi-directional Sporlan model EBVT with access fitting. Valves shall

be rated for 700psig, shall be U.L. listed, suitable for full refrigeration service temperature range of -40°F to 325°F. Valves shall include the following additional features:

- i. Welded body joint with forged brass body construction with extended copper fittings.
- ii. Dual Teflon seals.
- iii. Full size ports to minimize pressure drop.
- iv. ¼ turn operation with stainless steel stop plate.
- v. Internal ball relief port to allow positive shut-off in either direction, even during system evacuation.
- vi. Suitable for R-410A refrigerant.
- vii. Date code stamped into valve body.
- m. Pressure Relief Valves: Straight-through or angle pattern, brass body and disc, neoprene seat, and factory sealed and ASME labeled for standard pressure setting.

4. Cooling Coil A/C Condensate Drain and Floor Drain Piping that is Collecting A/C Condensate Piping:

- a. Pipe & Fittings: All A/C condensate drain piping, including floor drain piping that is collecting A/C condensate, shall be constructed of Type L copper tubing, with sweat fittings made with 95-5 solder. Washout plugs (cleanouts) shall be strategically located to allow periodic flush out of system. At a minimum, provide washout plugs at equipment connections and at direction changes of 90 degrees F or greater.
- b. Provide backwater valve (ball float type) at connections of condensate piping to stormwater piping and air gap fitting. Backwater valve shall be Model Z1099 as manufactured by Zurn or approved equal. Backwater valve shall have drain coated cast iron body, plastic ball float, bronze backwater bushing and replaceable neoprene seat.

5. Gas Fired Condensing Boiler Condensate Piping

- a. Piping shall be PVC pipe, ASTM D1785 schedule 40 with ASTM D2466 socket fittings for schedule 40. Join PVC pipe/fittings utilizing solvent cement ASTM D2564 with ASTM F656 primer.
- B. Steel pipe shall be similar and equal to National Tube Company, Grinnell, Republic, or Bethlehem black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.
- C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.

2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES

- A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260 for pipe ¾-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271.

Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - 1/2	6	8	3/8
2	8	8	3/8
2 - 1/2	10	9	1/2
3	12	10	1/2
4	14	12	5/8
5	14	12	5/8
6	16	14	3/4
8	18	16	7/8

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
10	20	18	7/8
12	20	18	7/8

- B. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.
- C. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring.
- D. Hangers for cold pipe sizes 2 inches (50 mm) and over: Carbon steel, adjustable, clevis.
- E. Hangers for cold pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.
- F. Hangers for cold pipe sizes 6 inches (150 mm) and over: adjustable steel yoke, cast iron roll, double hanger.
- G. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.
- H. Multiple or Trapeze hangers for hot pipe sizes 6 inches (150 mm) and over: Steel channels with welded spacers and hanger rod, cast iron roll.
- I. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook
- J. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp.
- K. Wall support for hot pipe sizes 6 inches (150 mm) and over: welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.

- L. Vertical Support: Steel riser clamp.
- M. Floor support for cold pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- N. Floor support for hot pipe sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- O. Floor support for hot pipe sizes 6 inches (150 mm) and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- P. Copper pipe support: Carbon steel ring, adjustable, copper plated.
- Q. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
- R. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
- S. For exterior pipe supports provide stainless steel brackets and anchors.

2.3. HYDRONIC EXPANSION LOOPS

- A. Provide hydronic flexible expansion loops of size and material noted on drawings as manufactured by Metroloop or approved equal. Flexible loops shall be designed to impart no thrust loads on the anchors. The loop shall consist of two flexible sections of hose and braid, two 90 degree elbows, and a 180 degree return. Loops shall be installed in a neutral, precompressed, or pre-extended condition as required for application. Loops are to be installed within four pipe diameters, both upstream and downstream, from a pipe guide.
- B. Where indicated provide nested loops and support the 180 degrees return bend. Nested loops shall be sized to absorb the axial compression movement as scheduled on the contract drawings.

2.4. VALVES

- A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer.
- B. Check valves in base mounted pump discharges shall be of the vertical type and shall be Victaulic Series 716/ W715, Miller "non-slam" check valves, Apollo/Shurjoint SJ-900, or approved equal suitable for service intended. Check valves in circulator discharges shall be horizontal type.
- C. Provide at each base mounted pump a suction diffuser of size and type shown on drawings. Units shall consist of a ductile cast iron angle type body with inlet vanes, magnetic insert, and blowdown connection tapped gauge post, 125 psi ANSI flange and a combination stainless steel diffuser strainer with 5/32 or 3/16-inch diameter opening for pump protection. Unit shall be equipped with a disposable fine 20-mesh stainless steel start up strainer which shall be removable after 30 days. Flow direction shall be from inside the strainer to outside for ease of service and cleaning. The body shall fit the pump and

connecting pipe size. The unit shall be provided with a base support boss or an adjustable support foot to relieve piping strains from the pump suction. Suction diffuser shall be Victaulic 731 Series, Taco "SD" Series Catalog 300-4.1, Bell and Gossett Model FLG, Armstrong, Patterson, Apollo/Shurjoint 725F, or engineer approved equal.

- D. Multi-purpose valve (non-slam check valve, throttling valve, shut-off valves and calibrated balancing valve) shall be provided at discharge side of constant speed pumps. The valve shall be of heavy-duty cast iron construction with standard ANSI flanged connections and rated for a maximum working pressure of 175 psig at 240°F. The valve shall be fitted with a stainless steel stem or stem sleeve and brass seat with "O" ring seal. Valve shall be Taco "Plus One" Number 300-4.2, Bell and Gossett 3DS Triple Duty Valve, Armstrong, Patterson, or as approved equal, and shall have check and plug valve features plus a memory stop with pointer and scale. Provide additional shut-off valve to allow servicing of check valve if a multipurpose valve is utilized in lieu of separate check, shut-off, and balance valve. Provide additional shut-off valve downstream of multi-purpose valve to allow servicing of multi-purpose check valve feature. Provide pre-manufactured, removable insulation covers for all multipurpose valves.
- E. Triple Duty Valve Assembly: Assembly shall consist of a Victaulic Master Seal, Apollo/Shurjoint SJ-900, or approved equal butterfly valve with memory stop and a Series 779 Venturi-Check, rated for water service to 230 degrees Fahrenheit (110 degrees Celsius) and pressures to 300 psig (2065-kPa).
 - 1. For 14" through 24" sizes, Victaulic AGS-Vic300, Apollo/Shurjoint SJ-300N-L/SJ-300N-W, or approved equal butterfly valve with Series W715 AGS check valve, rated for pressures to 230 psig (1575-kPa).
- F. Do not install multipurpose valves or balance valves on the discharge of variable speed pumps.

2.5. STRAINERS

- A. Strainers shall be of the basket or "Y" type and shall be heavy and durable, constructed of ductile iron to ASTM A536 or the best grade gray iron with the bottoms drilled and plugged. Bodies shall have arrows clearly cast on the sides to show flow direction. Strainers shall be equipped with easily removable covers and brass sediment baskets made of stainless steel or brass not less than #22 gauge in thickness. Total area of basket perforations shall be not less than four times the cross section of the entering pipe. Flow shall be into basket, and then out through the perforations. Strainers shall be suitable for water or the intended fluid. Strainers 2 inches and smaller shall have threaded or solder ends, 2 inches and larger shall have flanged ends.
- B. Strainer screens shall be stainless steel with perforations and shall be 1/16-inch for pipe sizes 5 inches and less, 1/8-inch (40 percent open area) perforations for pipe sizes 6-inch and greater.
- C. Provide valved and capped (with chain) blowdowns in each strainer. Blowdown valves shall be Apollo 78-100/200 series or as approved equal.
- D. Strainers shall be manufactured by Victaulic Style 732/W732, Watts, Mueller, Armstrong, Yarway, Spirax/Sarco, Apollo/Shurjoint 726, or as approved equal.

2.6. UNIONS, FLANGES, AND COUPLINGS

- A. Unions in steel pipe 2-inches and smaller shall be malleable iron with brass inserted seats designed for a working pressure of 150 psig.
- B. Unions in copper pipe 2-inches and smaller shall be sweat fittings with bronze seats designed for a working pressure of 125 psig.
- C. Unions in stainless steel pipe 2-inches and smaller shall be hexagonal threaded type stainless steel unions, with VicPress ends. Basis of Design: Victaulic Style P584.
- D. Flanges for steel pipe over 2 inches shall be 150 psig, forged steel, slip on. Gaskets shall be 1/16 inch thick pre-formed neoprene.
- E. Flanges for copper pipe over 2 inches shall be bronze. Gaskets shall be 1/16 inch thick preformed neoprene.

2.7. MANUAL AIR VENTS

- A. Manual air vents shall be similar to the hereinafter specified gauge valves. Provide 1/4-inch size on 3/4-inch pipe and smaller, 1/2 -inch size on 1-inch pipe and larger. Install at all high points of piping. Valves shall be Crane No. 88, or as approved equal, with threaded ends, bronze body, bronze or brass bonnet and bronze stem.

2.8. AUTOMATIC AIR VENTS

- A. Provide at air separators, expansion tanks and where shown on the drawings, float actuated non-modulating high capacity air vent to purge free air from the system and provide a positive shut-off at pressures up to 150 psig at a maximum temperature of 250 degrees Fahrenheit. The high capacity air vent shall prevent air from entering the system if the system pressure drops below atmospheric pressure. The air vent shall be pilot operated for intermittent purging of free air up to pressures of 2 psig during normal system operation and diaphragm operated for full capacity purging of free air at pressures between 2 and 150 psig. The high capacity air vent shall be constructed of cast iron and fitted with components of type 313 stainless steel, brass, EPDM and silicone rubber. Pipe discharge to closest floor drains with Type K copper tubing. The high capacity vent shall be Model 107 by Bell and Gossett, Model 13w by Spirax Sarco, Taco, Spirotherm Spirotop, or as approved equal.

2.9. THERMOMETERS

- A. Unless otherwise indicated, thermometers shall be ASTM E1, in a glass type, organic filled, 9-inch scale size, corrosion-resistant metal case, with "any-angle" mounting with positive locking device. Terence Industrial Thermometers, Weksler Instruments, Ernst Gage Co., Miljoco, or approved equal. Insertion stem length shall suite the pipe size and configuration. Thermometer wells shall be brass with brass union hubs in copper and in ferrous piping. Where piping is insulated or otherwise covered, use wells with lagging extension. Where wells are installed in pipe tees at turns, increase pipe size so that well does not restrict flow. Accuracy shall be 2 percent.
- B. Unless otherwise indicated, thermometer ranges shall be as follows:

1. Geothermal (Condenser Water) systems: 0 degrees F to 100 degrees Fahrenheit, 1 degrees Fahrenheit Division
 2. Heating Water: 30 degrees Fahrenheit to 240 degrees Fahrenheit, 2 degrees Fahrenheit Division.
- C. Provide heat conducting compound in wells.

2.10. PRESSURE GAUGES

- A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.
- B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.
- C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.
- D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.
- E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.11. FLOW METERS

- A. Griswold or Bell & Gossett Venturi disturbed flow measurement quickset flow meters shall be utilized in lieu of sentinel type flow meters. Units shall consist of a spun steel venturi welded into the pipe. Disturbed fluid shall be channeled through the throat of the venturi with a multi-point Piezo Ring. Accuracy shall be $\pm 1\%$ PSID with no straight pipe run required. Furnish differential pressure gauge supplied with carrying case and hoses.

2.12. PIPING SPECIALTIES

- A. Furnish and install flexible pipe connections, as specified and/or shown on the drawings, at suction and discharge connections of all base mounted and vertical in-line pumps, connections to heat pumps, all vibrating equipment, and elsewhere as shown. Pump flexible connections shall be utilized at pumps and hose kits at heat pumps. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for specifications.
- B. Pressure relief valves shall be provided in the number and sizes required to relieve 110 percent of the full input to the systems. Valves shall be rated; and installed in accordance

with ASME, and CSD-1 including all amendments. Pipe discharge full size to floor drain, (with union) and support discharge pipe to prevent exerting any strain on relief valve body, piping to be Type-L copper. Water safety relief valves shall be Watts Series 740, Conbraco, Series 154A, Bell and Gossett, or approved equal. Provide pressure gauge adjacent to all safety relief valves.

- C. Gas relief valve piping shall be sized and installed in accordance with the latest edition of ASME Boiler & Pressure Vessel Code, CSD-1 including amendments. Pipe material shall be as specified for gas piping. Gas relief valve piping material shall be the same as hereinbefore specified for gas piping.

2.13. ESCUTCHEONS

- A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.
- B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.14. DIELECTRIC CONNECTIONS:

- A. Furnish and install electrically insulated dielectric waterway fittings, unions or flanges, as manufactured by Victaulic Company Style 47, EPCO Sales, Inc., or approved equal at the following locations:
 - 1. Where steel piping systems join copper piping.
 - 2. Where copper tube connects to domestic water storage tanks, water heaters, heat exchangers, expansion tanks, and other steel vessels.
 - 3. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.
 - 4. Dielectric Waterway: Copper silicon casting conforming to UNS C87850 with grooved and/or threaded ends. UL classified in accordance with NSF-61 for potable water service, and shall meet the low-lead requirements of NSF-372. Basis of Design: Victaulic Series 647.

2.15. SLEEVES

- A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.
- B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend 3/4-inch above the floor. Refer to Division 23

Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for mechanical equipment room penetrations additional requirements. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.

- C. Sleeves through walls and floors shall be sealed with a waterproof caulking compound.
- D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.16. PRESSURE REDUCING VALVES

- A. Provide pressure reducing valves as indicated, of size and capacity selected by the installer to maintain operating pressure on the system. Body shall be cast-iron or bronze construction, renewable stainless steel seat, non-corrosive disc, water tight cage assembly, adjustable pressure ranges and inlet strainer Watts Regulator Model 223-S, Armstrong, Bell and Gossett, Apollo 36LFPR, or as approved equal.
- B. Provide pressure gauge adjacent to all pressure reducing valves to verify proper set point.

2.17. WATER PROOF PIPE PENETRATION SEALS

- A. Provide and install waterproof pipe penetration seals at all pipes that enter the building below grade or through exterior wall.
- B. Link seals are to be Metraflex Metraseals, Model MS, Linkseal, or approved equal, black EPDM seal material, glass reinforced plastic pressure plates, zinc plated nuts and bolts, seals are to be resistant to sunlight and ozone, pressure rated to make a hydrostatic seal of up to 20 psig and up to 40 feet of head, temperature rated from -40 degrees F to 250 degrees Fahrenheit.

2.18. TEST PLUGS

- A. Where indicated, furnish and install P/T plugs or Pete's Plugs as manufactured by IMAC Systems or approved equal.
- B. Description: Nickel-plated, brass-body test plug in NPS 2 (DN15) fitting. Test plugs shall be as manufactured by Trerice, Watts, Natural Meter, Apollo Brass Test Plugs, or approved equal. Test-station fitting made for insertion in piping tee fitting.
- C. Body: Length as required to extend beyond insulation. Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: NPS ¼ (DN 8) or NPS ½ (DN15) as required, ASME B1.20.1 pipe thread.
- E. Pressure Rating: 500 psig minimum.
- F. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- G. Core Inserts: One or two self-sealing valves, suitable for inserting 1/8 inch OD probe from dial-type thermometer or pressure gage. Chlorosulfonated polyethylene synthetic and

EPDM self-sealing rubber.

- H. Core Insert: Self-sealing valve, suitable for inserting 1/8 inch OD probe from dial-type thermometer or pressure gage.
- I. Core Material for Air, Water, Oil, and Gas: 20 to 300 degrees F chlorosulfonated polyethylene synthetic rubber.
- J. Test-Plug Cap: Gasketed and threaded cap, with retention chain or strap.
- K. Pressure Gage and Thermometer Ranges: approximately two times the system's operating conditions.
- L. Self-closing valves with caps and retaining straps.

2.19. FLO-CONTROL VALVES

- A. Furnish and install flo-control valves as shown on contract drawings to prevent gravity circulation in forced hot water systems. Flo-control valves shall be Bell & Gossett flo-control valves, TACO flo checks, or approved equal.
- B. Flo-control valves shall be suitable for installation in vertical or horizontal piping. Disc shall be precision machined bronze. Valve seats shall be heavy wall brass. Flo-control valves shall be suitable for a maximum operating temperature of 275 degrees F and a maximum working pressure of 125 psig. Flow-control valves shall not be selected based on line size. Select flow-control valves at design flow rate to limit pressure drop to 6 Ft head.
- C. Flo-control valves shall be constructed to allow cleaning without breaking pipe connections. Flo-control valves shall be installed with clearances from center line of valves to ceiling as required by manufacturer. Flo-control valves shall feature a manual open position for gravity circulation.

2.20. TRANSITION FITTINGS

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Plastic-to-Metal Transition Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Charlotte Pipe and Foundry Company.

- b. Harvel Plastics, Inc.
 - c. Spears Manufacturing Company.
 - 2. Description: PVC or CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket end.
- D. Plastic-to-Metal Transition Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Colonial Engineering, Inc.
 - b. NIBCO INC.
 - c. Spears Manufacturing Company.
 - 2. Description: PVC or CPVC four-part union. Include brass threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

- A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All horizontal mains shall pitch down in the direction of flow with a grade of not less than 1 inch in 40 feet. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, coils, etc., and installed so that there will be no interference with the installation of the equipment, ducts, etc. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.
- B. All piping shall be graded to convey entrained air to high points where automatic air vents shall be provided. The size of supply and return pipes for each piece of equipment shall in no case be smaller than the outlets in the equipment.
- C. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.
- D. All valves, strainers, caps, and other fittings shall be readily accessible.

- E. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.
- F. Discharge lines from all relief valves shall be piped to within 4-inches of floor and extend to floor drains wherever floors are not pitched to drains. Pitch the relief valve piping away from the relief valve to insure that no fluid can be trapped in valve discharge. Support all relief valve piping to prevent exerting strain on the relief valve body. The end of the relief valve discharge piping shall not be threaded to prevent capping or plugging.
- G. All branches from water mains shall be taken from the top of the supply mains at an angle of forty-five (45) degrees above the horizontal, unless otherwise directed. Branches feeding down shall be taken from the side or bottom of the main on water mains only. All connections shall be carefully made to insure unrestricted circulation, eliminate air pockets or trapped condensate, and permit the complete drainage of the system.
- H. Cutoff valves shall be provided on each branch line from the mains on all heating/air conditioning lines.
- I. Shut-off valves shall be installed at the inlet and outlet of each coil and piece of equipment to permit isolation for maintenance and repair. Units having multiple coils shall have separate valves for each coil.
- J. Balancing valves shall be installed in all heating/air conditioning water branches and at all pumps, and where indicated on the drawings.
- K. Unions shall be installed on all bypasses, ahead of all traps, at all connections to equipment, where shown on drawings or where required to facilitate removal of equipment whether shown or not.
- L. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.
- M. If the size of any piping is not clearly evident in the drawings, the Contractor shall request instructions for the Engineer as to the proper sizing. Any changes resulting from the Contractor's failure to request clarification shall be at his expense. Where pipe size discrepancies or conflicts exist in the drawings, the larger pipe size shall govern.
- N. Approved expansion loops shall be provided to permit free expansion and contraction of all piping systems.
- O. Install all valves with stem upright or horizontal, not inverted.
- P. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.
- Q. Provide clearance for installation of insulation and access to valves and fittings.
- R. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

- S. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.
- T. Provide manual air vents at top of piping systems.

3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.

- A. Install thermometers and adjust vertical and tilted positions.
- B. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.
 - 1. Install with socket extending to one-third diameter of pipe.
 - 2. Fill sockets with oil or graphite and secure caps.
- C. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.
- D. Adjust faces of thermometer and gages to proper angle for best visibility.
- E. Clean windows of thermometer and gages and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.
- F. Do not attempt to repair defective valves; replace with new valves.
- G. Install valves as indicated, according to manufacturer's written instructions.
- H. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.
- I. Install valves with unions or flanges at each piece of equipment arranged to allow servicing,

maintenance, and equipment removal without system shutdown.

- J. Locate valves for easy access and provide separate support where necessary.
- K. Install valves in horizontal piping with stem at or above the center of the pipe.
- L. Install valves in a position to allow full stem movement.
- M. For chain wheel operators, extend chains to 60 inches above finished floor elevation.
- N. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.
- O. Install flow control valves with clearances from center line of valve to ceiling to allow servicing as required by manufacturer.

3.4. REFRIGERANT PIPING AND ACCESSORIES INSTALLATION REQUIREMENTS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise. All exposed piping shall be hard copper tubing with brazed joints. Refer to Architectural Contract Documents to determine exposed areas.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to units to allow service and maintenance.
- G. Install piping free of sags and bends. Install VEE clevis hangers and VEE troughs on pipes less than ¾" inch in diameter.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified if valves or equipment requiring maintenance is concealed behind finished surfaces.

- L. Install refrigerant piping in protective conduit where installed below ground.
- M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- N. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- O. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- Q. Identify refrigerant piping and valves.
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section, "Common Work Results for HVAC".
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section, "Common Work Results for HVAC".
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section, "Common Work Results for HVAC".
- U. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6m) long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6m) or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6m) or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

- V. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
1. NPS ½ (DN 15): Maximum span, 60 inches (1500mm); minimum rod size, ¼ inch (6.4mm).
 2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500mm); minimum rod size, ¼ inch (6.4mm).
 3. NPS 1 (DN 25): Maximum span, 72 inches (1800mm); minimum rod size, ¼ inch (6.4mm).
 4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).
 5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).
 6. NPS 2 (DN 50): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).
 7. NPS 2-½ (DN 65): Maximum span, 108 inches (2700mm); minimum rod size, 3/8 inch (9.5mm).
 8. NPS 3 (DN 80): Maximum span, 10 feet (3m); minimum rod size, 3/8 inch (9.5mm).
 9. NPS 4 (DN 100): Maximum span, 12 feet (3.7m); minimum rod size, 1/2 inch (13mm).
- W. For all interior refrigerant pipe/tubing that is less than 3/4inch in diameter, utilize VEE type clevis hanger Model 200 V and VEE type trough Model 200 VT; as manufactured by Carpenter and Patterson or approved equal. VEE trough materials shall be carbon steel with pre-galvanized finish. Install as required to maintain maximum hanger spacing requirements.
- X. Support multifloor vertical runs at least at each floor.
- Y. Furnish and install complete refrigerant piping systems between the indoor units and outdoor units, branch selector boxes, indoor units, and compressor units. Support piping in accordance with Division 23 Section, HVAC Piping, Fittings, Valves, Etc. Piping shall be sized as recommended by unit manufacturer taking into account length of vertical and horizontal runs, and refrigerant type. Provide and install dual sets of refrigerant piping on all units required to have dual independent circuits.
- Z. Furnish and install all required piping accessories including, but not limited to, thermal expansion valves, Sporlan, or approved equal; Packless isolation valves at condenser and evaporator coil, Henry or approved equal, charging valve with chained seal cap, Henry or approved equal, sight glasses, Henry or approved equal; filter dryer with replaceable cartridge, Sporlan, or approved equal, liquid line solenoid valve 120V/1/60 Hz., Sporlan, or approved equal. Contractor shall provide traps and double suction risers if required by

- equipment manufacturer. Pitch piping for proper oil return. Submit shop drawings on all components, and piping arrangements.
- AA. All accessories shall be ARI rated. Furnish required nitrogen and refrigerant to fully test and charge system. Flood piping system with nitrogen when brazing.
 - BB. Refrigerant piping shall be Type 1 hard temper (ACR) copper tubing with wrought copper brazed fittings. Make joints with brazed wrought copper fittings.
 - CC. Refrigerant piping shall be cleaned, dehydrated and evacuated. Piping shall be evacuated and held to less than 2.5 mm Hg vacuum for a period of not less than 12 hours without appreciable pressure rise. Vacuum shall then be broken with refrigerant or dry nitrogen and re-evacuated to 2.5 mm Hg vacuum for an additional 12 hours. Piping test to be witnessed by Owner's representative and documented in writing. Submit results of tests to Architect/Engineer.
 - DD. All refrigerant/suction lines sets shall be fully insulated. Exterior pipe insulation shall be fully jacketed as specified in Division 23 Section, "HVAC Insulation". Exposed interior pipe insulation shall be fully jacketed as specified in Division 23 Section, "HVAC Insulation".
 - EE. Follow ASHRAE 15, latest edition procedures for charging and purging of systems and for disposal of refrigerant.
 - FF. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.
 - GG. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
 - HH. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
 - II. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.
 - JJ. Fully charge completed system with refrigerant after tested.
 - KK. Provide electrical connection to solenoid valves.
 - LL. Install liquid indicators in liquid line leaving condenser, in liquid line leaving receiver, and on leaving side of liquid solenoid valves.
 - MM. Install strainers immediately upstream from each automatic valve, including expansion valves, solenoid valves, hot-gas bypass valves, and compressor suction valves.
 - NN. Install strainers in main liquid line where multiple expansion valves with integral strainers are used.
 - OO. Install strainers in suction line of steel pipe.
 - PP. Install moisture-liquid indicators in liquid lines between filter-dryers and thermostatic expansion valves and in liquid line to receiver.

- QQ. Install flexible connectors at or near compressors where piping configuration does not absorb vibration.
- RR. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.
1. Test refrigerant piping, specialties and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure.
 2. Test high- and low-pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.
 - a. System shall maintain test pressure at the manifold gage throughout duration of test.
 - b. Test joints and fittings by brushing a small amount of soap and glycerin solution over joint.
 - c. Fill system with nitrogen to raise a test pressure of 150 psig (1035 kPa) or higher as required by authorities having jurisdiction.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- SS. Adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.
- TT. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- UU. Adjust set-point temperature of the conditioned air or chilled-water controllers to the system design temperature.
- VV. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
 2. Check compressor oil level above center of sight glass.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves, except bypass valves that are used for other purposes.
 5. Check compressor-motor alignment, and lubricate motors and bearings.
- WW. Before installing copper tubing other than Type ACR, clean tubing and fittings with trichloroethylene.
- XX. Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.
- YY. Charge system using the following procedures:
1. Install core in filter-dryer after leak test but before evacuation.

2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

3.5. PIPE JOINTS INSTALLATION REQUIREMENTS

- A. Welded Joints: Joints in piping 2-1/2-inches and larger shall be fusion welded. Welding shall be in accordance with recommendations of the American Welding Society. Welding fittings shall conform in physical and chemical properties to the latest revisions of the American Society for Testing Materials.
- B. Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9 as applicable, for shop and project site welding of piping work. Certify welding of piping work using Standard Procedure Specifications by, and welders tested under supervision of, National Certified Pipe Welding Bureau (NCPWB). Submit welders qualifications for approval.
- C. Grooved Joints: Grooved joint shall be installed in accordance with the manufacturer's written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)
- D. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.
- E. Soldered Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.
 1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.
 2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.
 3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.

4. The correct amount of solder per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.
 5. Solder joints shall be made by using a direct flame from a torch.
 6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the solder starts to melt to insure an even distribution of the solder.
 7. The excess solder shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.
 8. Solder joints shall be suitable for working pressure of 100 psig and for working temperature of not less than 250 degrees F. The type of solder and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.
 9. Lead and antimony-based solders shall not be used for potable water systems. Brazing and silver solders are acceptable.
- F. Where copper piping joins steel piping, approved bronze adapters shall be used.
- G. Prohibited Connections: No direct weld, soldered, or brazed connections, without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

3.6. HANGERS , SUPPORTS, ANCHORS, GUIDES INSTALLATION REQUIREMENTS

- A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Provide protection saddles between hangers and insulation on heating water insulated pipe. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal.
- B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping. For cast iron soil pipe, one hanger shall be placed at each hub or bell.
- C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.
- D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and

bracket systems in their entirety shall be galvanized.

- E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.
- F. Select hangers and components for loads imposed. Secure rods with double nuts.
- G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.
- H. Support overhead piping with clevis hangers.
- I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.
- J. Install guides on piping adjoining expansion fittings and loops.
- K. Attach guides to pipe and secure to building structure.
- L. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- M. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.
- N. Construct concrete anchors of poured in place concrete of dimensions indicated and include embedded fasteners.
- O. Install pipe anchors according to expansion fitting manufacturer's written instructions if expansion fittings are indicated.
- P. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.
- Q. Refer to structural documents for appropriate connection/attachment materials to building.

3.7. AIR VENTING INSTALLATION REQUIREMENTS

- A. The top of each hydronic water supply and return piping and other points as indicated or where necessary for the removal of air from the system or equipment, shall be vented using an approved type of manual air vent.
- B. In addition to manual air vents at high points of system, each item of water heat transfer equipment shall be manually vented using an approved type manual air vent. All air vents shall be accessible.

3.8. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS

- A. Install expansion fittings according to manufacturer's written instructions.
- B. Install expansion fittings in sizes matching pipe size in which they are installed.
- C. Align expansion fittings to avoid end loading and torsional stress.

- D. Install pipe bends and loops cold sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- E. Attach pipe bends and loops to anchors.
 - 1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.
- F. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- G. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- H. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.9. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS

- A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.
- B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
$\frac{1}{2}$ to $1\frac{1}{4}$	8	$\frac{1}{2}$
$1\frac{1}{2}$ to 2	8	$\frac{3}{4}$

2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.10. VALVE IDENTIFICATION REQUIREMENTS

- A. All valves shall be tagged with a numbered tag.
- B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.
- C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.
- D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in each mechanical equipment room including each air handling unit mechanical equipment room. Additional copies shall be provided in each copy of the O&M manuals.

3.11. CLEANING PIPING AND EQUIPMENT

- A. All condensate, heating water, HVAC, geothermal condenser water, systems shall be cleaned by filling with a solution of one (1) pound of trisodium phosphate to each 50 gallons of water and circulating this solution for a period of six (6) hours during which time the system shall reach operating temperature. The systems shall then be flushed with fresh water and refilled with fresh water and/or where indicated antifreeze solution and purged of all air.
- B. All condensate, heating water, HVAC, geothermal condenser water, piping system shall be flushed clean with fresh water. See Division 22 Sections, Plumbing Fixtures and Plumbing Equipment for domestic potable water cleaning and sterilization. Where indicated, hydronic systems shall be filled with 30 percent by volume antifreeze.
- C. Any equipment, such as coils that have small tubing, shall be bypassed to prevent deposition of debris from the piping. Water balancing shall not be scheduled until the completion of the cleaning and treatment process.
- D. All strainers shall be inspected and cleaned prior to testing and balancing. In addition, prior to substantial completion, contractor must inspect and clean all strainers.

3.12. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS

- A. Viega, ProPress Pressure Seal bronze or copper fittings: Sealing element shall be verified for the intended use. Tube ends shall be cut on a right angle (square) to the tube. Tube ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the tube

end with a clean rag. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting. Utilizing a Viega Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings ½-inch thru 4-inch shall be installed according to the most current edition of the Viega installation guidelines, using appropriate sized rigid ProPress tools. Installers shall attend a Viega ProPress installation training class.

- B. After ProPress Pressure Seal fittings have been installed a “two step test” shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings. Should you identify an un-pressed fitting ensure the tube is fully inserted into the fitting, and properly marked, prior to pressing the joint. After appropriate repairs have been made, retest the system per specification requirements, not to exceed 600 psi with water.

END OF SECTION

DIVISION 23 SECTION 23 05 48
VIBRATION CONTROLS FOR HVAC, PLUMBING & FIRE PROTECTION EQUIPMENT
TABLE OF CONTENTS

PART 1. RELATED DOCUMENTS.....	2
1.1. GENERAL.....	2
1.2. SUMMARY.....	2
1.3. SUBMITTALS	2
1.4. PROJECT RECORD DOCUMENTS.....	3
1.5. COLOR CODING	3
1.6. ALTERNATES	3
PART 2. PRODUCTS.....	3
2.1. MANUFACTURER.....	3
2.2. CORROSION PROTECTION FOR STEEL PARTS	3
2.3. SPRING MOUNTS AND SOUND PADS	3
2.4. SPRINGS.....	3
2.5. NEOPRENE	3
2.6. FLOOR MOUNTED ISOLATORS:	3
2.7. SPRING ISOLATORS	4
2.8. SUSPENSION ISOLATORS	4
2.9. THRUST RESTRAINTS.....	4
2.10. INERTIA BASES	5
2.11. FLEXIBLE CONNECTORS FOR PIPING.....	5
2.12. NEOPRENE PAD ISOLATORS.....	7
2.13. RUBBER MOUNTS.....	7
PART 3. EXECUTION.....	7
3.1. GENERAL PROVISIONS	7
3.2. PIPE ISOLATION.....	9
3.3. BOILER, MECHANICAL, FAN AND EQUIPMENT ROOM SOUND ISOLATION.....	10
3.4. FLEXIBLE PIPE CONNECTORS	11
3.5. ISOLATION FOR SPECIFIC EQUIPMENT.....	11
3.6. MANUFACTURER'S FIELD SERVICES.....	12
END OF SECTION	12

SECTION 23 05 48

VIBRATION CONTROLS FOR HVAC, PLUMBING AND FIRE PROTECTION EQUIPMENT

PART 1. RELATED DOCUMENTS

1.1. GENERAL

- A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to work of this section.
- B. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC.

1.2. SUMMARY

- A. Provide all labor and materials necessary to furnish and install vibration control systems on this project as herein specified and/or shown on the drawings.
- B. Mount all mechanical equipment on suitable vibration isolators so as to prevent transmission of vibration into or through the building structure. Isolators shall be as manufactured by Mason Industries, Inc., Korfund, Inc., Amber Booth, Vibration Mounting and Controls, or approved equal, and shall be selected by the isolator manufacturer for each item of equipment in accordance with requirements hereinafter specified.
- C. The equipment manufacturer shall supply all pump and motor bases, fan and motor bases, cradles, isolation pipe/duct hangers, spring and/or neoprene isolators, neoprene pads, flexible connectors, etc. as a coordinated package by a single manufacturer.
- D. Select isolators for uniform static deflections according to distribution of weight; and for not less than the indicated isolation efficiency with the lowest rotational speed of equipment as the disturbing frequency.
- E. Isolators and bases shall be stable during stopping and starting of equipment without transverse or eccentric movement of equipment, and shall be designed to resist horizontal forces of equipment which may operate unbalanced.
- F. In general, select isolators on the basis of criteria as specified in the ASHRAE Applications Handbook, Latest Edition.

1.3. SUBMITTALS

- A. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each.
- B. Product Data: Provide schedule of vibration isolator type with location and load on each.
- C. Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.
- D. Manufacturer's Certificate: Certify that isolators are properly installed and adjusted to meet or exceed specified requirements.

1.4. PROJECT RECORD DOCUMENTS

- A. Record actual locations of hangers including attachment points.

1.5. COLOR CODING

- A. All springs shall be color coded for load carrying capacity.

1.6. ALTERNATES

- A. Refer to Division 01 Section, Alternates - Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS**2.1. MANUFACTURER**

- A. Isolators shall be the equivalent of the following types by Mason Industries, Inc., Korfund, Inc. or approved equal.

2.2. CORROSION PROTECTION FOR STEEL PARTS

- A. Where steel parts are exposed to weather or humid environments provide hot-dipped galvanized coating of at least 2 ounces of zinc per square foot of surface. Coat springs with neoprene.

2.3. SPRING MOUNTS AND SOUND PADS

- A. Provide all spring mounts with leveling devices, minimum .25 inch thick neoprene sound pads, and zinc chromate plated hardware.
- B. All sound pads shall be size for minimum deflection of .05 inch; meet requirements for neoprene pad isolators.

2.4. SPRINGS

- A. All springs shall have minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between .3 and .6 of maximum deflection.

2.5. NEOPRENE

- A. Grade durometer 40, 50 OR 60 AND OIL RESISTANT.

2.6. FLOOR MOUNTED ISOLATORS:

- A. Neoprene Isolation Pads: Provide pads at least ¼ " thick with cross-ribbed or waffle design. For concentrated loads provide steel bearing plates bonded or cold cemented to the pads. Neoprene isolation pads shall be Type Super W.
- B. Neoprene Isolators: Rubber (neoprene)-in-shear mounting: Provide molded neoprene isolators having steel base plates with mounting holes and, at the top, steel mounting plates with mounting holes or threaded inserts. Provide elements of type and size coded with

molded letters or color-coded for capacity identification. Embed metal parts completely in neoprene. Double deflection neoprene mountings shall have a minimum static deflection of 0.35". Bolt holes shall be provided for these areas where bolting is required. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above the mounting to compensate for the over-hang. Mountings shall be type ND or rails type DNR.

2.7. SPRING ISOLATORS

- A. General: Provide spring isolators or protected spring isolators that are adjustable and laterally stable with free-standing springs of horizontal stiffness at minimum 80 percent of the vertical (axial) stiffness. For machine-attached and floor-attached restraining elements, separate from metal-to-metal contact by neoprene cushions 1/8 inch thick minimum. Provide neoprene acoustic friction pads at least ¼ inch thick.
- B. Spring Isolator: Spring type isolators shall be free standing and laterally stable without any housing and complete with ¼ " neoprene acoustical friction pads between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflections, compressed spring height and solid spring height. Mountings shall be type SLF as manufactured by Mason Industries, Inc. or as approved equal.

2.8. SUSPENSION ISOLATORS

- A. General: Provide hangers with suspension isolators encased in open steel brackets. Isolate hanger rods from isolator steel brackets with neoprene-lined opening.
- B. Suspension Neoprene Isolators: Provide double-deflection elements with minimum 3/8 inch deflection.
- C. Suspension Spring Isolators: Vibration hangers shall contain a steel spring and 0.3" deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing thru a 30o arc before contacting the hole and short circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include a scale drawing of the hanger showing the 30o capability. Hangers shall be type 30N.
- D. Precompressed Suspension Spring Isolators: Vibration hangers shall be as described in "C" above, but they shall be precompressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a scale drawing of the hanger showing the 30o capability. Hangers shall be type PC30N.

2.9. THRUST RESTRAINTS

- A. Adjustable spring thrust restraints, able to resist the thrust force with at least 25 percent unused capacity. The operating spring deflection shall be not less than 50 percent of the

static deflection of the isolation supporting the machinery. The spring element shall be contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" movement at start and stop. The assembly shall be furnished with one rod and angle bracket for attachment to both the equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrically on either side of the unit. Horizontal thrust restraints shall be type WB.

2.10. INERTIA BASES

- A. Structural Bases: Vibration isolator manufacturer shall furnish integral structural steel bases. Bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. All perimeter members shall be beams with a minimum depth equal to 1/10th of the longest dimension of the base. Beam depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of one inch- bases shall be type WF.
- B. Structural Rails: Vibration isolator manufacturer shall provide steel members welded to height saving brackets to cradle machines having legs or bases that do not require a complete supplementary base. Members shall be sufficiently rigid to prevent strains in the equipment. Inverted saddles shall be type ICS.
- C. Concrete Bases: Vibration isolator manufacturer shall furnish rectangular structural beam or channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. In general, bases shall be a minimum of 1/12th of the longest dimension of the base, but not less than 6". Forms shall include minimum concrete reinforcement consisting of half inch bars or angles welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom, or additional steel as is required by the structural conditions. Forms shall be furnished with steel members to hold anchor-bolt sleeves when the anchor bolts fall in concrete locations. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base. Concrete shall be 3,000 psi concrete. Mass of concrete inertia bases shall be minimum of 2 times weight of isolated equipment. Bases shall be type K.

2.11. FLEXIBLE CONNECTORS FOR PIPING

- A. General: Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.
- B. Elastomeric Flexible Connectors: Flexible neoprene connectors shall be manufactured of multiple plies of nylon tire cord fabric and neoprene both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement. Straight connectors shall have two spheres. Connectors up to and including 1 1/2 " diameter may have threaded ends. Connectors 2" and larger shall be manufactured with floating

galvanized flanges recessed to lock the connector's raised face neoprene flanges. Hoses shall be installed on the equipment side of the shut-off valves. Connectors shall be rated a minimum of 150 psi at 220oF. Flanged equipment shall be directly connected to neoprene elbows in the size range 2 ½ " through 12" if the piping makes a 90o turn at the equipment. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure. 12" and larger sizes operating above 100 psi shall employ control cables with end fittings isolated by means of ½ " thick bridge bearing neoprene washer bushings designed for a maximum of 1000 psi.

- C. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies.
- D. Elbows shall be Mason-Flex type MFNEC, straight connectors Mason-Flex type MFTFU or MFTNC, and control cable assemblies type ACC.
- E. Metal Flexible Connectors: Fabricated of Grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover. Sizes 3" and larger shall be flanged. Sizes 2 ½ " and smaller shall have male nipples. Lengths shall be as indicated:

Nominal Diameter (Inches)	Length (Inches)
½ "	12"
¾"	12"
1 ½ "	12"
1 ½ "	12"
2"	12"
2 ½ "	12"
3"	18"
4"	18"
5"	24"
6"	24"
8"	24"
10"	24"

12"	36"
14"	36"
16"	36"

- F. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be type BSS.

2.12. NEOPRENE PAD ISOLATORS

- A. Rubber or neoprene waffle pads.
1. 30 durometer
 2. Minimum 2 inch (13mm) thick
 3. Maximum loading 40 psi (275 kPa)
 4. Height of ribs shall not exceed 0.7 times width.
- B. Configuration: ½ inch (13mm) thick waffle pads bonded each side of ¼ inch (6 mm) thick steel plate.

2.13. RUBBER MOUNTS

- A. Molded rubber designed for 0.6 inches (13 mm) deflection with threaded insert.

PART 3. EXECUTION

3.1. GENERAL PROVISIONS

- A. Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.
- B. Where neoprene elements of vibration isolator may be subjected to high pipe temperatures above 160°F, provide metal heat shields or thermal isolators.
- C. A minimum of 4" thick reinforced concrete housekeeping pads shall be provided under all floor mounted equipment. A minimum of 6" thick reinforced concrete housekeeping pads shall be provided under all boilers, and where indicated. Rest subbases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both ends. Provide at least one (1) inch clearance between subbases and inertia bases, steel bases, and steel saddles with machinery in operation.
- D. All vibration isolators exposed to weather or humid environment shall be hot dipped galvanized with springs coated with neoprene in accordance with paragraph hereinbefore described.
- E. Concrete inertia bases shall be a minimum of two (2) times the weight supported. Clearance between the underside of the inertia base and the housekeeping pad below shall not be less than 1 inch. Concrete shall be 3000 psi. Install inertia bases in accordance with

the recommendations of the machinery manufacturer and the inertia base manufacturer.

- F. Anchor Bolts and Grout: Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.
- G. Common Machinery Foundations: Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.
- H. Thrust Restraints: Where required, provide pairs of thrust restraints, symmetrically installed on both sides of the steady state line of thrust.
- I. Machinery: Provide vibration isolators, flexible connectors and seismic snubbers in accordance with manufacturer's recommendations. Machinery with spring isolators or protected spring isolators shall rock or move freely within limits of stops or seismic snubber restraints.
- J. Stability: Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.
- K. Lateral Motion: The installed vibration isolation systems for each piece of floor or ceiling mounted machinery shall have a maximum lateral motion under machinery start up and shut down conditions of not more than $\frac{1}{4}$ -inch. Restrain motions in excess by approved spring mountings.
- L. Unbalanced Machinery: Provide foundation suspension systems specifically designed to resist horizontal forces for machinery with large unbalanced horizontal forces. Vibration isolator systems shall conform to the machinery manufacturer's recommendations.
- M. Nonrotating Machinery: Mount nonrotating machinery in systems which includes rotating or vibrating machinery on isolators having the same deflection as the hangers and supports for the pipe connected to.
- N. Roof and Upper Floor Mounted Machinery: On the roof or upper floors, mount machinery on isolators with vertical stops. Rest isolators on beams or structures designed and installed in accordance with the SMACNA ASMM Plate 61.
- O. Vibration isolation ceiling hangers shall be installed so that the hanger rods do not touch the sides of the isolator housing, thereby seriously degrading the vibration isolation performance. Vibration isolation ceiling hangers shall be located so that the hanger housing may rotate 360o without touching any object.
- P. Electrical Connections: Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit 2 inch minimum displacement in any direction without damage.
- Q. Systems Not To Be Vibration Isolated: Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping

systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

- R. Install in accordance with manufacturer's instructions.
- S. Install isolation for motor driven equipment.
- T. Bases:
 - 1. Set steel bases for one inch (25mm) clearance between housekeeping pad and base.
 - 2. Set concrete inertia bases for 2 inch (50mm) clearance between housekeeping pad and base.
 - 3. Adjust equipment level.
- U. Install spring hangers without binding.
- V. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.
- W. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.
- X. Connect wiring to isolated equipment with flexible hanging loop.

3.2. PIPE ISOLATION

- A. Horizontal Pipe Isolation:
 - 1. Precompressed Suspension Spring Isolators:
 - a. For the first three pipe hangers in the main lines near the mechanical equipment provide precompressed suspension spring isolators. Floor supported piping shall rest on trained spring isolators. All precompressed suspension spring isolators hangers or the first three trained spring isolators mounts as noted above, will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceiling under occupied spaces, the first three hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1.5" deflection for pipe sizes up to and including 6" and 2.5" deflection thereafter. All other hangers and mounts will have a minimum steel spring deflection of 0.75". Hangers shall be located as close to the overhead supports as practical.
 - 2. Combination Spring and Neoprene Suspension Hanger:
 - a. For horizontal runs in other than those hereinbefore specified provide suspension spring hangers (combination spring and neoprene) with .75" minimum steel spring deflection.
 - b. Hot and Geothermal Interior Heat Pump Piping:

- i. For the first 20 feet of the branch connection of the main supply and return piping at each floor.
 - ii. For all piping over 2" diameter.
- B. Floor-Supported Piping:
 1. Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use vibration isolators as described hereinbefore and selected to the guidelines of hangers.
 2. The first three adjacent floor supports shall be the restrained spring type with a blocking feature that prevents load transfer to equipment flanges as the piping is filled and drained.
 3. Where piping is subject to larger thermal movement a slide plate shall be installed on the top of the isolator. Slide plate shall be teflon, graphite or steel.
 4. Provide a thermal barrier where neoprene products are installed directly beneath steam or hot water lines.
- C. Pipe Risers: Provide pipe riser supports with bearing plates and two layers of ¼ " thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with ¼ " steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.
- D. Supports at Base of Pipe Risers: Piping isolation supports at the base of risers shall be two layers of ½" thick heavy-duty neoprene pad separated by ¼ " thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.
- E. Pipe Anchors: Attach each end of the pipe anchor to an omni-directional pipe isolator which in turn shall be rigidly fastened to the steel framing or structural concrete. Provide a telescoping pipe isolator of two sizes of steel tubing separated by a minimum ½ " thick pad of heavy-duty neoprene or heavy-duty neoprene and canvas. Provide vertical restraints by similar material to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.3. BOILER, MECHANICAL, FAN AND EQUIPMENT ROOM SOUND ISOLATION

- A. Do not allow direct contact between pipes or ducts and walls, floor slabs, roofs, ceilings or partitions of equipment rooms.
- B. Pipe Penetrations: All piping passing through mechanical equipment room and fan room walls, floors and ceilings shall be protected against sound leakage by means of an acoustical wall seal as described hereinbefore and fire stopping.

- C. Duct Penetrations: Provide with sound insulation equal to the sound attenuation value of the wall, floor, or ceiling penetrated.

3.4. FLEXIBLE PIPE CONNECTORS

- A. Provide flexible connectors in accordance with manufacturers instructions where piping systems serving vibration isolated equipment and as shown on the drawings. Flexible connectors shall be installed near the connection to the equipment. Where liquid pulsation dampening is required, flexible connectors with spherical configuration may be used. Provide restraints for pipe connectors at pumps to prevent connector failure upon pump start-up.

3.5. ISOLATION FOR SPECIFIC EQUIPMENT

- A. The vibration isolator manufacture shall provide isolators for all pieces of equipment provided for the job. Isolator shall be selected by the isolator manufacturer on the basis of criteria as specified in the ASHRAE Applications Handbook, latest edition, unless a more stringent requirement is indicated on the drawings.
- B. Pumps:
 - 1. All base mounted pumps shall be mounted on concrete inertia blocks supported on stable steel springs in series with ribbed neoprene pads selected for not less than 1.5 inch static deflection under full operating load. Mason Industries type SLF or as approved equal.
 - 2. Floor support of the initial pipe elbows at the pump discharge and suction diffuser at the pump intake shall be made from the isolated inertia base, not from the equipment room floor. Mason Industries Type K or as approved equal.
 - 3. Provide flexible pipe connections at pump suction and discharge. Mason Industries Type BSS or MFTNC/MFTFU with control rods type ACC or as approved equal.
 - 4. Provide discharge and suction vibration isolaters at all vertical in-line pumps.
- C. Fans:
 - 1. Fans up to 22" wheel diameter shall be mounted stable steel springs in series with ribbed neoprene pads selected for not less than 1.5" static deflection (Mason Industries Type SLF or equivalent).
 - 2. Fans with wheel diameters 24" and greater shall be mounted on unhoused stable steel springs in series with ribbed neoprene pads and structural rails selected for not less than 2.5" static deflection (Mason Industries Type SLF or equivalent and structural rails Type ICS with thrust restraint provisions) and rails shall be Type ICS.
 - 3. All fans suspended from the ceiling, joists or roof structure, including outside air fans, return fans, relief air, ventilation fans, and exhaust fans, shall be suspended using hangers incorporating steel springs in series with neoprene, selected for not

less than 3.5" static deflection under full load (Mason Industries Type 30N or equivalent).

- D. All horizontal, vertical, and recessed unit heaters shall be suspended using hangers incorporating steel springs in series with neoprene selected for not less than 1" static deflection under full load (Mason Industries Type 30N or equivalent).
- E. Ductless Units: Indoor ductless units shall be supported with rubber grommet type suspension isolators. Outdoor ductless units shall be supported on ribbed neoprene pads resting on roof curbs (roof application).

3.6. MANUFACTURER'S FIELD SERVICES

- A. Inspect isolated equipment after installation and submit report. Include static deflections.

END OF SECTION

DIVISION 23 SECTION 23 05 93
TESTING, ADJUSTING & BALANCING FOR HVAC & PLUMBING

TABLE OF CONTENTS

PART 1.	GENERAL	1
1.1.	GENERAL.....	1
1.2.	EXAMINATION.....	3
1.3.	QUALIFICATIONS OF THE BALANCE AGENCY	3
1.4.	PRE-BALANCING CONFERENCE	4
1.5.	STANDARDS	4
1.6.	COORDINATION.....	4
1.7.	INSTALLATION TOLERANCE.....	4
1.8.	RESPONSIBILITIES OF THE MECHANICAL CONTRACTOR	5
1.9.	RESPONSIBILITIES OF THE TEMPERATURE CONTROL CONTRACTOR	6
1.10.	NOTIFICATION FOR TESTING AND BALANCING WORK TO BEGIN	7
1.11.	DEFICIENCIES	7
1.12.	ADJUSTING	7
1.13.	ALTERNATES	8
1.14.	GENERAL COMMISSIONING REQUIREMENTS.....	8
PART 2.	PRODUCTS (NOT APPLICABLE)	8
PART 3.	EXECUTION	8
3.1.	GENERAL.....	8
3.2.	EXAMINATION.....	8
3.3.	AIR SYSTEM PROCEDURES	10
3.4.	WATER SYSTEM PROCEDURES.....	11
3.5.	DOMESTIC HOT WATER RE-CIRCULATING SYSTEMS PROCEDURES	13
3.6.	TESTING AND BALANCING OF EXISTING SYSTEMS	14
3.7.	FIRE AND SMOKE TESTING PROCEDURES	14
3.8.	LIFE SAFETY CONTROLS TESTING PROCEDURES	14
3.9.	VERIFICATION OF TEMPERATURE CONTROL	14
3.10.	TEST AND BALANCE REPORTS	15
3.11.	TEST REPORT FORMS	16

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC AND PLUMBING

PART 1. GENERAL

1.1. GENERAL

- A. This section covers performance testing, adjusting and balancing of heating, ventilating, air conditioning and domestic re-circulating systems as specified in Division 23 Section, Heating, Ventilating, and Air Conditioning Equipment and in Division 22 Section, Plumbing Fixtures and Plumbing Equipment.
- B. For Common Work Results of HVAC, See Division 23. See Division 01 for General Requirements.
- C. The mechanical contractor shall select and employ an impartial, independent balancing agency to provide testing and balancing services for the heating, ventilating and air conditioning (HVAC) systems and other specified systems of this project.
- D. The work included in this section consists of furnishing labor, instruments, and tools required in testing, adjusting and balancing the HVAC and plumbing systems, as described in these specifications or shown on accompanying drawings. Services shall include checking equipment performance, taking the specified measurements, and recording and reporting the results.
- E. The items requiring testing, adjusting, and balancing include, but are not limited to, the following:

Air Systems:

- 1. Air Flow Monitoring Stations
- 2. Coils (Air Temperatures & Static Pressure Drops)
- 3. Diffusers, Registers and Grilles
- 4. Ductless Split System Units (Indoors and Outdoor units)
- 5. Energy Recovery Ventilators
- 6. Existing Re-Located Electric Unit Heaters
- 7. Exhaust Fans
- 8. Geothermal Rooftop Heat Pumps
- 9. Hot Gas Re-heat Coils
- 10. Heat Pumps
- 11. Power Relief Fans

12. Rooftop Units
13. Supply Fan AHU
14. Unit Heaters
15. Variable Refrigerant Volume Systems
16. Ventilation Fans
17. Rooftop water source heat pumps.
18. Zone Branch and Main Ducts

Hydronic Systems:

1. Boilers
2. Coils
3. Condensate Receiver Pumps
4. Condensate Pumps
5. Condensate overflow safety switches
6. Condenser Water Pumps
7. Differential Pressure Bypass Valves
8. Domestic Re-circulating Systems
9. Elevator Pit Sump Pump
10. Energy Recovery Ventilators
11. Flow Measuring Stations
12. Freeze Protection Pumps
13. Flow Meter Fittings
14. Geothermal Rooftop Heat Pump
15. Glycol Feed Pumps
16. In-line Pumps
17. Pumps
18. Rooftop water source heat pumps.

19. System Mains and Branches
20. Elevator Sump Pumps
21. Unit Heaters
22. In addition, any existing fans, equipment or air devices specified to be re-used under this project shall be tested and balanced, similar to new fans.

1.2. EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 1. Systems are started and operating in a safe and normal condition.
 2. Temperature control systems are installed complete and operable.
 3. Proper thermal overload protection is in place for electrical equipment.
 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 5. Duct systems are clean of debris.
 6. Fans are rotating correctly.
 7. Fire dampers, smoke dampers, and volume dampers are in place and open.
 8. Air coil fins are cleaned and combed.
 9. Access doors are closed and duct end caps are in place.
 10. Air outlets are installed and connected.
 11. Duct system leakage is minimized.
 12. Hydronic systems are flushed, filled, and vented.
 13. Pumps are rotating correctly.
 14. Proper strainer baskets are clean and in place.
 15. Service and balance valves are open.
- B. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.
- C. Beginning of work means acceptance of exiting conditions.

1.3. QUALIFICATIONS OF THE BALANCE AGENCY

- A. The balancing agency shall be a member of the Associated Air Balance Council (AABC).
- B. The certified test and balance engineer shall be responsible for supervision and certification for the total work herein specified.
- C. All final reports shall be signed by the certified test and balance engineer.

1.4. PRE-BALANCING CONFERENCE

- A. Convene a conference one week prior to commencing work of this Section with all appropriate individuals.

1.5. STANDARDS

- A. The balancing agency shall perform the services specified herein in accordance with the Associated Air Balance Council's National Standards, including revisions, to the date of the contract.
- B. All terms in this specification shall have their meaning defined as stated in the National Standards.
- C. ADC: Test Code for grilles, registers, and diffusers.
- D. ASHRAE III: Practice for measurement, testing, adjusting and balancing of building heating, ventilation, air conditioning, and refrigeration systems.
- E. NEBB: Procedure standards for testing, adjusting, and balancing of environmental systems.
- F. SMACNA: HVAC systems testing, adjusting, and balancing.
- G. AABC: Associated Air Balance Council

1.6. COORDINATION

- A. It will be necessary for the balancing agency to perform its services in close coordination with the mechanical contractor.
- B. The plans and specifications have indicated meters, valves, dampers, and other devices for the purpose of adjusting the system to obtain optimum operating conditions. It will be the responsibility of the mechanical contractor to install these devices in a manner that will leave them accessible and readily adjustable. The balancing agency shall provide guidance if there is a questionable arrangement of a control or balancing device.
- C. The general contractor, mechanical contractor, temperature control contractor and suppliers of the HVAC equipment shall all cooperate with the balancing agency to provide all necessary data on the design and proper application of the system components.
- D. For heat pumps, the manufacturer's start-up agency and Test and Balance Engineer shall assist each other with obtaining proper flow rates and refrigerant pressures.

1.7. INSTALLATION TOLERANCE

- A. Unless otherwise indicated, all air devices shall be adjusted to within plus or minus 10 percent of design. All fans shall be adjusted to within plus or minus 5 percent of design. All pumps and Hydronic equipment shall be adjusted to within plus or minus 5 percent of design.

1.8. RESPONSIBILITIES OF THE MECHANICAL CONTRACTOR

- A. The mechanical contractor shall sufficiently complete the installation and start all HVAC systems to insure they are working properly and shall perform all other items as described hereinafter to assist the balancing agency in performing the testing and balancing of the HVAC system.
- B. Record equipment manufacturer's standard start-up information and submit to Engineer for review. Testing and balancing work shall not commence on any equipment until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.
- C. Air Distribution Systems
 - 1. Verify installation for conformity to design.
 - 2. Terminate all supply, return, outside air, exhaust air, relief air, ventilation air ducts, and pressure test them for leakage. Test pressure and leakage rate shall be as specified in Division 23 Section, HVAC Air Distribution System under Leakage Tests. Pressure testing shall be performed by mechanical contractor and witnessed by Test and Balance Engineer.
 - 3. Ensure that all volume dampers, fire dampers, and smoke damper are properly located and functional. Dampers serving requirements of minimum and maximum outside - return - relief, and exhaust air shall provide tight closure and full opening, with a smooth and free operation.
 - 4. Verify that all supply - return - exhaust and transfer grilles; registers, and diffusers are installed and operational.
 - 5. Ensure that air-handling systems, units, and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., are blanked and/or sealed to eliminate excessive bypass or leakage of air.
 - 6. Ensure that all fans are operating and free of vibration. All fans and drives shall be checked for proper fan rotation and belt tension. Overload protection shall be of proper size and rating. A record of motor current and voltage shall be made to verify that the motors do not exceed nameplate rating. Record thermal overload ratings for all motors in the Test and Balance Report.
 - 7. Make any necessary changes to the sheaves, belts, and dampers, as required by the balancing agency, at no additional cost to the owner.
 - 8. Install clean filters.
 - 9. For heat pumps, provide refrigerant suction and discharge pressure to Test and

Balance Engineer for inclusion in the final TAB Report.

D. Water Circulating Systems

1. Verify installation for conformity to design.
2. Check all pumps to verify pump alignment and rotation.
3. Ensure that systems are clean, with the proper strainer screens installed for normal operation.
4. Check all pump motors for current and voltage, to ensure that motors do not exceed nameplate rating.
5. Provide thermal overload protection of proper size and rating. Record thermal overload ratings for all motors. Insert data in Test and Balance Report.
6. Ensure that all water circulating systems shall be full and free of air; that expansion tanks are set for proper water level; and that all air vents were installed at high points of systems and are operating.

1.9. RESPONSIBILITIES OF THE TEMPERATURE CONTROL CONTRACTOR

- A. The temperature control contractor shall complete the installation of the temperature control system, and operate and test all control systems to ensure they are functioning properly as designed. The temperature control contractor shall assist the balancing agency in testing and balancing the HVAC systems, as described hereinafter.
1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, freeze stats and duct smoke detectors.
 2. Verify that all controlling instruments are calibrated and set for design operating conditions.
 3. Calibrate temperature sensors after installation, and before the temperature sensors control verification tests are performed. The balancing agency shall prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditional space for each separately controlled zone.
 4. The temperature control contractor shall allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing and balancing work can be performed.
- B. All control sequences, software, equipment, and components shall be started-up by a qualified technician. Start-up report shall be submitted to Engineer prior to the commencement of testing and balancing work. Testing and balancing shall not commence until start-up reports are completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

1.10. NOTIFICATION FOR TESTING AND BALANCING WORK TO BEGIN

- A. The mechanical contractor shall notify the balancing agency in writing when all heating, ventilating, and air conditioning systems are complete and ready for testing and balancing. The mechanical contractor shall attest that he has completed all items as herein described.
- B. The following must be completed prior to start of system balancing:
 - 1. All duct work and associated grilles/registers/diffusers installed and completed.
 - 2. Piping systems completed, flushed and filled.
 - 3. Equipment properly started by qualified personnel or start-up technicians.
 - 4. Ceiling tiles installed.
 - 5. Automation system (temperature controls) installed and completed for both air and water systems.
 - 6. All equipment controlled in automatic ("Auto") mode.
 - 7. Access granted to the balancing contractor to the automation/controls system provided.

1.11. DEFICIENCIES

- A. Any deficiencies in the installation or performance of a system or component observed by the TAB agency shall be brought to the attention of the appropriate responsible person.
- B. The work necessary to correct items on the deficiency listing shall be performed and verified by the affected Contractor before the TAB Agency returns to retest. Unresolved deficiencies shall be noted in the final report.

1.12. ADJUSTING

- A. Ensure recorded data represents actual measured observed conditions.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring all sensors to specified settings.
- E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.
- F. Check and adjust systems approximately six months after final acceptance and submit report.

- G. Permanently mark the locations of all duct traverses on the exterior surface of the duct insulation.

1.13. ALTERNATES

- A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

1.14. GENERAL COMMISSIONING REQUIREMENTS

- A. Refer to Division 01 Section, "General Commissioning" for description of work under this Division affected by General Commissioning.

PART 2. PRODUCTS (NOT APPLICABLE)

PART 3. EXECUTION

3.1. GENERAL

- A. Perform all testing and balancing in complete accordance with AABC National Standards for Field Measurements and Instrumentation.
- B. Furnish all test instruments and equipment. All instruments must have been calibrated within twelve (12) months prior to use and shall be checked for accuracy prior to and during the work. Submit certificate for calibration of all equipment utilized on project with date of calibration clearly identified.
- C. Review all systems designs and equipment, manufacturers' data, and be completely familiar with the work before proceeding.
- D. Report all malfunctions or deficiencies to the contractor so that corrective action can be taken. Test and Balance Report shall not be submitted for review until all malfunctions or deficiencies are corrected. Repeat tests where required until design conditions are achieved.
- E. Where systems or equipment cannot be balanced or adjusted to design conditions, determine the cause and submit a complete report to the Engineer.
- F. Retest or rebalance the system as required during the warranty period.
- G. Test and balance all systems under adequate load condition. If, in the opinion of the Engineer, there is insufficient load to properly test and balance the systems, perform sufficient preliminary balancing and adjustment to permit operation of the systems until such time as final testing and balancing can be done. Provide in writing the future date when systems shall be tested under sufficient load.
- H. At project completion provide a complete set of 1/2 scale drawings indicating the locations of all duct traverses.

3.2. EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to

discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

- B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems – Duct Design". Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, and verify that they are accessible and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens are replaced by permanent screens and indicated perforations.
- L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.

- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3. AIR SYSTEM PROCEDURES

- A. The balancing agency shall perform the following testing and balancing functions in accordance with the Associated Air Balance Council's National Standards:
1. Fan Speeds - Test and adjust fan RPM to achieve design CFM requirements.
 2. Current and Voltage - Measure and record motor current and voltage. Check and record thermal overload ratings for all motors.
 3. Pitot-Tube Traverse - Perform a Pitot-tube traverse of main supply, return and exhaust ducts to obtain total CFM. If a Pitot-tube traverse is not practical, the summation of the outlets or inlets may be used. An explanation why a traverse was not made must appear on the appropriate data sheet.
 4. Outside Air - Test and adjust system minimum outside air by Pitot-tube traverse. If a Pitot-tube traverse is not practical, the percentage of outside air may be determined by calculations from the return air, outside air, and mixed air temperatures. Make allowances for heat of compression and motor heat where applicable.
 5. Static Pressure - Test and record system static pressures, including suction and discharge static pressure of each fan. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make fan RPM allowances for 50 percent loading of filters.
 6. Air Temperature - Take wet-bulb and dry-bulb air temperatures on the entering and leaving side of each cooling coil and/or heat recovery coil. Dry-bulb temperature shall be taken on the entering and leaving side of each heating coil.
 7. Zone Ducts - Adjust zone ducts to within design CFM requirements. At least one zone balancing damper shall be completely open.
 8. Main Ducts - Adjust main ducts to within design CFM requirements and traverse for total CFM quantities.
 9. Branch Ducts - Adjust branch ducts to within design CFM requirements. Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.
 10. Magnahelic Gauges - Static pressure at static pressure tips for Magnahelic gauges shall be recorded in Test and Balance Reports.
 11. Tolerances - Test and balance each diffuser, grille, and register to within 10 percent of design requirements. Test and balance all fans to within 5 percent of design requirements.

12. Identification - Identify the location and area of each grille and diffuser, register. This information shall be recorded on air outlet data sheets.
13. Description - Record the size, type, and manufacturer of each diffuser, grille, and register on air outlet data sheets.
14. Minimizing Drafts - Adjust all diffusers, grilles, and registers to minimize drafts in all areas.
15. Test and Balance Engineer shall witness and record all leakage testing of ductwork. Leakage test data shall be included in final Test and Balance Reports.
16. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable air volume systems at maximum air flow rate, full cooling, and at minimum airflow rate, full heating.
17. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
18. For heat pumps, assist start-up organization or manufacturer's representative with start-up. Record air flow rates, water flow rates and electrical characteristics prior to refrigerant pressure measurement and settings.
19. For all equipment specified with condensate overflow safety switches/floats test operation of such device and record results. Verify interlock with ATC system.
20. Outside air and exhaust/relief air measurements must be measured and submitted in all modes of operation including the following:
 - a. Min Min Outside Air/Exhaust/Relief air mode (square footage outside air).
 - b. Min Max Outside Air/Exhaust/Relief air mode (square footage and people outside air).
 - c. Maximum outside air/exhaust/relief mode (full 100% economizer mode).
21. For all outside air modes of operation record and submit full static pressure profiles, amperage, BHP, air flow rates, external static pressure, and internal static pressure. Verify airflow rates with air flow monitoring stations and record results.

3.4. WATER SYSTEM PROCEDURES

- A. The various water circulating systems shall be filled, purged of air, and put into operation before hydronic balancing by the mechanical contractor.
- B. The flow of water through all coils shall be adjusted by manipulating balancing valves until the rated pressure drop through the coil or metering device is obtained. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- C. The balancing agency shall perform the following testing and balancing functions in accordance with the AABC National Standards.
- D. All Hydronic equipment, domestic re-circulating pumps, and HVAC pumps shall be Tested

and Balanced as described below:

1. Water Treatment - Examine the water in the system and determine if the water has been treated and cleaned. If it has not, request the mechanical contractor to clean and treat the water prior to TAB work
2. Strainers - Request that the mechanical contractor clean all strainers.
3. Air Vents - Check all air vents at the high points of the water system and determine if they are installed and operating.
4. Valves - Set all balancing valves to the full-open position for balancing.
5. Pumps - Adjust all pumps and domestic hot water re-circulating water pumps to meet design GPM requirements. Check pumps for proper operation. Pumps shall be free of vibration and cavitation. Measure and record operating current and voltage. Check and record thermal overloads installed on all pumps. Record in Test and Balance Report.
6. Tolerances - Proceed to balance all coils, pumps and balance valves boilers to within 5 percent of design requirements.
7. Marking - Mark all settings and record all data after completing the flow readings and coil adjustments.
8. Where available pump capacity (due to diversity) is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.
9. Test and verify proper operation of oil sensors at elevator pit sump pump and report results.
10. Test all A/C condensate pumps for proper operation.
11. Test condensate overflow safety switches.

E. Boilers:

1. Verify that boilers have been filled and started by others, and are in operation.
2. Current and Voltage - As applicable, test and record motor voltage and amperage, and compare data with the nameplate limits to ensure motor is not in or above the service factor.
3. Test and adjust water flow through water boilers.
4. Test and record temperature and pressure profiles of water boilers.

F. Geothermal Heat Pump Test Forms - Record the following items on each geothermal heat pump test form:

1. Manufacturer model number, serial numbers.

2. All design and manufacturer's rated data.
 3. Service and location.
 4. Actual pressure drop and design pressure drop of condenser/evaporator coils.
 5. Entering and leaving water fluid of condenser/evaporator coils.
 6. Temperature control settings.
 7. Electrical characteristics.
 8. Test hot gas re-heat coil and record temperatures entering and leaving unit.
- G. Exterior Geothermal Heat Pump U-Tube Test Form:
1. Entering temperature, design and actual.
 2. Leaving temperature, design and actual.
 3. Primary water flow, design and actual.
 4. Primary water pressure drop, design and actual.
- H. Coils:
1. Tolerances - Test, adjust, and balance all hydronic coils within 5 percent of design requirements.
 2. Verification - Verify the type, location, final pressure drop and GPM of each coil. This information shall be recorded on coil data sheets.

3.5. DOMESTIC HOT WATER RE-CIRCULATING SYSTEMS PROCEDURES

- A. The domestic hot water re-circulating system shall be tested and balanced as indicated on the contract documents including:
1. Balance of circuit setters to design quantities indicated on contract documents.
 2. Balance of re-circulating pumps to meet design GPM requirements.
- B. Domestic Water Heaters/Generators:
1. Verify that all existing domestic water heaters have been filled and started by others and are in operation.
 2. Test and record outlet temperature of existing water heater at approximate design recovery.
 3. Current and Voltage: As applicable, test and record voltage and amperage, compare data with nameplate limits to ensure water heater elements or burners do not exceed nameplate data.

4. Test discharge temperature and flow rate at all lavatory/hand sink mixing valves. Also measure time period for fixtures to obtain hot water.

3.6. TESTING AND BALANCING OF EXISTING SYSTEMS

- A. The balancing agency shall perform testing and balancing of existing air handling, fan and pump systems to the extent indicated. Existing air devices and terminals shall be re-tested and balanced where effected by new ductwork modifications.
- B. Test and Balance Agency shall assist the mechanical contractor in selection of new sheaves and belts, if required. Re-sheaving of existing air handling units or fans shall be done at no additional cost to owner. Where required, new sheave and belt size calculations shall be forwarded to the Engineer for review and approval.
- C. The Test and Balance Agency shall perform air system procedures (here-in before specified) on the following existing systems.
 1. Existing Cafeteria HVAC Units.
 2. Existing Re-Located Electric Unit Heaters.
- D. The Test and Balance Agency shall perform water system procedures (here-in before specified) on the following hydronic systems.
 1. Existing Geothermal Pumps.
 2. Existing Cafeteria HVAC Units.

3.7. FIRE AND SMOKE TESTING PROCEDURES

- A. The TAB agency shall test fire/smoke damper to assure operation. It shall verify that an access door has been installed for each fire and smoke damper. For fire dampers, the TAB agency shall open the access door, disconnect the fusible link, and allow the damper to close. Operation should be smooth and the damper must close completely. The TAB agency shall then reset the damper. For the smoke damper, the TAB agency shall open the access door, activate the damper, and observe operation. The damper must close quickly and completely. The TAB agency shall then reset the damper and observe its complete opening. Record results of tests within TAB report.

3.8. LIFE SAFETY CONTROLS TESTING PROCEDURES

- A. The TAB agency shall test and record life safety control operation on the HVAC equipment. It shall verify the installation of required smoke detectors in air handling equipment (AHE), and shall verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown. With the controls and alarm contractors, the TAB agency shall verify the operation of interconnected systems such as the AHU smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequences. Record results of tests within TAB report.

3.9. VERIFICATION OF TEMPERATURE CONTROL

- A. The balancing agency shall be assisted by the temperature control contractor in verifying the operation and calibration of all temperature control systems. The following tests shall be conducted:
 - 1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset.
 - 2. Verify that all controlling instruments are calibrated and set for design operating conditions.
 - 3. Verify the accuracy of the final settings by taking temperature readings. The readings shall be in a typical conditioned space for each separately controlled zone.
 - 4. Test and calibrate all air flow monitoring stations for proper air flow.
 - 5. Test and calibrate all static pressure sensors for proper set point and control.
 - 6. Test and calibrate all differential pressure sensors. Record set point in Record and Information Books.

3.10. TEST AND BALANCE REPORTS

- A. The test and balance report shall be complete with logs, data, and records as required herein. All logs, data, and records shall be typed on white bond paper and bound. The report shall be certified accurate and complete by the balancing agency's certified test and balance engineer.
- B. Six (6) copies of the test and balance report are required and shall be submitted to the Engineer. If, in the opinion of the Engineer, test results or portions thereof are incomplete or inconclusive, repeat necessary portions of the work to the satisfaction of the Engineer.
- C. The report shall contain the following general data in a format selected by the balancing agency:
 - 1. Project Number
 - 2. Contract Number
 - 3. Project Title
 - 4. Project Location
 - 5. Project Architect
 - 6. Project Mechanical Engineer
 - 7. Test & Balance Agency
 - 8. Test & Balance Engineer
 - 9. General Contractor/Construction Manager

10. Mechanical Subcontractor
 11. Dates tests were performed
 12. Certification
 13. Duct Leakage Tests
 14. Phone Numbers of all Individuals Listed Above
- D. The test and balance report shall be recorded on report forms conforming to the recommended forms in the AABC National Standards.

3.11. TEST REPORT FORMS

- A. Air Moving Equipment and Fan Test Forms - Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling geothermal heat pump equipment test form:
1. Manufacturer, model number, serial number, arrangement.
 2. All design and manufacturer-rated data.
 3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.
 4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, mixing boxes, and similar devices.
 5. Outside-air, return-air, and exhaust air total CFM.
 6. Actual operating current, voltage and brake horsepower of each fan motor. For packaged equipment, this includes supply fans, relief air fans, and condenser fans.
 7. Final RPM of each fan.
 8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.
 9. Belt size, quantity and make.
 10. Static-pressure controls final operating set points (if applicable).
 11. Total and external static pressure.
- B. Pump Test Forms - Submit pump curve showing design, operating, and no-flow points of operation. Also, record the following items on each pump test form:
1. Manufacturer, size, model, service and serial number.
 2. All design and manufacturer's rated data.

3. Pump operating suction and discharge pressure and final total dynamic head.
 4. No flow (pump discharge valve closed) suction and discharge pressure and corresponding total dynamic head. This procedure is to determine actual impeller size. Record impeller size.
 5. Rated and actual operating current, voltage, and brake horsepower of each pump motor.
 6. Total operating head pressure.
 7. Shutoff, discharge and suction pressures.
 8. Shutoff, total head pressure.
- C. Boiler Test Forms - Record the following items on each chiller and boiler test form:
1. Manufacturer model number, serial numbers.
 2. All design and manufacturer's rated data.
 3. Service and location.
 4. Actual pressure drop and related GPM primary side.
 5. Actual pressure drop and related GPM, secondary side.
 6. Primary side entering and leaving temperatures.
 7. Secondary side entering and leaving temperatures.
 8. Temperature control settings.
 9. Electrical characteristics.
- D. Heating and Cooling-Coil Test Forms - Record the following items on each test form:
1. Manufacturer, location, service.
 2. All design and manufacturer's rated data.
 3. Rated and actual water pressure drop through each coil and related GPM.
 4. Rated and actual static pressure drop across each coil.
 5. Rated and actual entering and leaving water temperatures across each coil.
 6. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil; dry-bulb temperatures entering and leaving each heating coil.
 7. Air flow (Design and Actual).

8. For DX-coil, provide design and actual saturated suction temperature.
 9. For DX-Coil, provide design and actual discharge pressures.
- E. Air Monitoring Station Test Forms:
1. Identification /location.
 2. Manufacturer.
 3. Systems.
 4. Size and Model Number.
 5. Area.
 6. Design Velocity.
 7. Design Airflow.
 8. Test Velocity.
 9. Test Airflow.
 10. Static Pressure Drop and Velocity Pressure.
 11. Station Calibrated Setting.
- F. Flow Measuring Station Test Forms:
1. Identification/location.
 2. Manufacturer.
 3. Size and Model Number.
 4. Design and Actual Flow Rate.
 5. Design and Actual Pressure Drop.
 6. ATC flow rate versus field measured flow rate.
- G. Electric Motors Test Forms: (Applies to all motors, including pumps, fans and HVAC equipment)
1. Manufacturer.
 2. Model/Frame.
 3. HP/BHP.
 4. Phase, voltage, amperage; nameplate, actual, no load.

5. RPM.
 6. Service factor.
 7. Starter size, rating, heater elements.
 8. Sheave Make/Size/Bore.
 9. Thermal overload settings
- H. V-Belt Drive Test Forms:
1. Identification/location.
 2. Required driven RPM.
 3. Driven sheave, diameter and RPM.
 4. Belt, size and quantity.
 5. Motor sheave diameter and RPM.
 6. Center to center distance, maximum, minimum, and actual.
- I. Duct Traverse Test Forms:
1. System zone/branch.
 2. Duct size.
 3. Area.
 4. Design velocity.
 5. Design air flow.
 6. Test velocity.
 7. Test airflow.
 8. Duct static pressure.
 9. Air temperature.
 10. Air correction factor.
- J. Duct Leakage Test Forms:
1. Description of ductwork under test.
 2. Duct design operating pressure.

3. Duct design test static pressure.
4. Duct capacity, air flow.
5. Maximum allowable leakage duct capacity times leak factor.
6. Test apparatus.
 - a. Blower.
 - b. Orifice, tube size.
 - c. Orifice size.
 - d. Calibrated.
7. Test static pressure.
8. Test orifice differential pressure.
9. Leakage.

K. Air Distribution Test Sheet:

1. Air terminal number.
2. Room number/location.
3. Terminal type.
4. Terminal size.
5. Area factor.
6. Design velocity.
7. Design air flow.
8. Test (final) velocity.
9. Test (final) air flow.
10. Percent of design air flow.

L. Ductless Unit Test Forms:

1. Manufacturer
2. Type, air conditioning, heat pump
3. Identification number
4. Location
5. All design and manufacturer's rated data.

6. Rated and actual entering and leaving dry bulb temperatures.
 7. Rated and actual entering and leaving wet bulb temperatures.
 8. Air flow (design and actual)
 9. Provide actual saturated suction temperature.
 10. Actual operating current, voltage and brake horsepower of each fan motor.
 11. Final fan RPM.
 12. For Air Cooled Variable Refrigerant Volume System test current, voltage, RPM, and breaker horsepower for outdoor unit.
- M. Energy Recovery Ventilators Test Forms: Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment test form:
1. Manufacturer, model number, serial number, arrangement.
 2. All design and manufacturer-rated data.
 3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.
 4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, energy wheels, and similar devices.
 5. Outside-air, and exhaust air total CFM.
 6. Actual operating current, voltage and brake horsepower of each fan motor.
 7. Final RPM of each fan.
 8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.
 9. Belt size, quantity and make.
 10. Total and external static pressure.
 11. Rated and actual static pressure drop across each energy wheel.
 12. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil, heat pipe and energy wheel. Dry-bulb temperatures entering and leaving each heating coil.
 13. For DX-coil, provide design and actual saturated suction temperature.
 14. Record carbon dioxide set points and actual readings for exhaust air stream at each ERV and global CO2 sensor.

15. Entering and leaving air temperatures at hot gas re-heat coils.
 16. Record the supply fan and exhaust fan maximum hertz/speed and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.
- N. Ground Heat Exchanger Test Forms:
1. Entering temperature, design and actual.
 2. Leaving temperature, design and actual.
 3. Primary water flow, design and actual.
 4. Primary water pressure drop, design and actual.
- O. Water to Air Heat Pump and Rooftop Heat Pump Test Form – Record the Following Items on Each Heat Pump Test Form:
1. Manufacturer model number, serial numbers.
 2. All design and manufacturer's rated data.
 3. Design and actual fluid pressure and related GPM.
 4. Ground loop entering and leaving temperatures, design and actual.
 5. Electrical characteristics, design, and actual.
 6. Suction pressure (provided by start-up agency).
 7. Discharge pressure (provided by start-up agency).
 8. Fan speed, static pressure voltage, amp draw.
 9. Wet Bulb and dry Bulb temperatures entering, leaving coil design, actual.
 10. For units with hot gas re-heat, entering/leaving temperatures at hot gas coil.
- P. Elevator Sump Pump Test Form:
1. Manufacturer, Model Number, and Serial Number.
 2. Motor Horsepower – Design/Actual
 3. Voltage/Phase/Hz/Amps
 4. Verify ATC interlocks.
 5. Test high water condition.
- Q. Air Cooled Condensing Unit Test Forms:

1. Manufacturer
 2. Model Number
 3. Location
 4. Size/Capacity
 5. Fan RPM (Min and Max)
 6. Compressor and Condenser/Heat Pump Fan Electrical Characteristics
 7. Condenser/Heat Pump Fan RPM
 8. Amp Draw of all Components
 9. Refrigerant Suction/Discharge Pressures
 10. Thermal Overload Sizes
- R. Thermostatic Mixing Valve Test Forms
1. Manufacturer, Model Number, Series, Arrangement
 2. All manufacturer data.
 3. Verify all strainers are clean.
 4. Leaving temperature actual and design.
- S. Existing Water Heater Test Forms
1. Manufacturer, Model Number, Series
 2. All manufacturers' data.
 3. Verify all safeties.
 4. Record leaving water temperature actual and design.
 5. Verify operation in all modes of operation.
 6. Verify combustion air damper interlock.
 7. Record electrical characteristics
- T. Condensate Over Flow Switches/Floats
1. Manufacturer
 2. Type

3. Location
 4. Equipment shut down verification
 5. ATC interlock verification
- U. Existing Re-Located Electric Unit Heater Test Forms:
1. Manufacturer.
 2. Identification/number.
 3. Location.
 4. Model number.
 5. Phase, voltage, amperage.
 6. Test voltage
 7. Test amperage
 8. Air flow, specified and actual.
 9. Temperature rise, specified and actual.

END OF SECTION

DIVISION 23 SECTION 230600
HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT
TABLE OF CONTENTS

PART 1.	GENERAL	3
1.1.	GENERAL	3
1.2.	DESCRIPTION	3
1.3.	SUBMITTALS	3
1.4.	OPERATION AND MAINTENANCE DATA	3
1.5.	DELIVERY, STORAGE, AND HANDLING	3
1.6.	ENVIRONMENTAL REQUIREMENTS	4
1.7.	ALTERNATES	4
1.8.	EXTRA MATERIALS	4
PART 2.	PRODUCTS	4
2.1.	AUTOMATIC GLYCOL MAKEUP SYSTEM	4
2.2.	INDUSTRIAL INHIBITED PROPYLENE GLYCOL	5
2.3.	GLYCOL FEEDER PRESSURE TANK	6
2.4.	FANS	6
2.5.	IN-LINE CIRCULATING PUMPS	10
2.6.	IN-LINE CLOSE COUPLED CIRCULATING PUMP	10
2.7.	VERTICAL IN-LINE PUMPS	11
2.8.	VARIABLE SPEED DRIVES	12
2.9.	COMBINATION COALESCING AIR AND DIRT SEPARATOR	15
2.10.	EXPANSION TANKS	16
2.11.	HORIZONTAL RECESSED CABINET UNIT HEATERS(WITH INTEGRAL SUPPLY/RETURN GRILLES)	16
2.12.	HORIZONTAL HOT WATER UNIT HEATERS	17
2.13.	EXTERIOR EQUIPMENT/DUCT SUPPORT	17
2.14.	EXTERIOR PIPE ROLLER SUPPORTS	17
2.15.	ROOF CURBS (DUCT PENETRATIONS)	17
2.16.	EXTERIOR ROOFTOP PIPING SUPPORT (NON-PENETRATING)	18
2.17.	AIR MONITORING STATIONS (ERV UNITS)	18
2.18.	WATER TREATMENT SERVICES	20
2.19.	ENERGY RECOVERY VENTILATORS	22
2.20.	WATER TO AIR GROUND SOURCE HEAT PUMPS (ROOFTOP UNITS)	27
2.21.	BOILER BUFFER TANKS	34
PART 3.	EXECUTION	35
3.1.	EXAMINATION	35
3.2.	GENERAL INSTALLATION REQUIREMENTS	35
3.3.	FIELD QUALITY CONTROL	36
3.4.	DEMONSTRATION	37
3.5.	CLEANING	37
3.6.	DUCTLESS UNITS EQUIPMENT INSTALLATION REQUIREMENTS	37
3.7.	ELECTRIC HEATING EQUIPMENT INSTALLATION REQUIREMENTS	38
3.8.	FAN INSTALLATION REQUIREMENTS	38
3.9.	BOILER INSTALLATION REQUIREMENTS	39
3.10.	HVAC PUMP INSTALLATION REQUIREMENTS	42
3.11.	HYDRONIC EQUIPMENT AND SPECIALITIES INSTALLATION REQUIREMENTS	43

3.12.	ROOFTOP UNITS INSTALLATION REQUIREMENTS.....	44
3.13.	WATER TREATMENT INSTALLATION REQUIREMENTS	45
3.14.	ENERGY RECOVERY VENTILATOR INSTALLATION REQUIREMENTS	46
3.15.	WATER SOURCE HEAT PUMP EQUIPMENT INSTALLATION REQUIREMENTS.....	47

SECTION 23 06 00**HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT****PART 1. GENERAL****1.1. GENERAL**

- A. The Conditions of the Contract and other General Requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC and Division 01 Section General Requirements.

1.2. DESCRIPTION

- A. The work to be performed shall include all labor, materials and equipment necessary to furnish and install complete, all mechanical equipment as shown on drawings, hereinafter specified or reasonably implied, and leaving the same in satisfactory operation condition. It is the intent that systems be installed complete with all items necessary to accomplish this purpose.

1.3. SUBMITTALS

- A. Shop Drawings: Indicate assembly, equipment dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- B. Product Data:
 - 1. Provide literature which indicates dimensions, weights, capacities, ratings, performance, gages and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Provide data of filter media, filter performance data, filter assembly, and filters frames.
 - 3. Provide fan and pump curves with specified operating point clearly plotted.
 - 4. Submit sound power level data for both fan outlet and casing radiation at rated capacity. Submit sound power levels by octave band or sound pressure levels by octave band for all equipment.
 - 5. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

1.4. OPERATION AND MAINTENANCE DATA

- A. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.5. DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of General Requirements.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store all equipment in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- D. Comply with manufacturer's installation instructions for rigging, unloading and transporting equipment.
- E. Protect all motors, shafts, and bearings from weather and construction dust.

1.6. ENVIRONMENTAL REQUIREMENTS

- A. Do not operate any equipment for any purpose, temporary or permanent, until ductwork/piping is clean, filters/strainers are in place, bearings lubricated, and equipment has been test run under observation.

1.7. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

1.8. EXTRA MATERIALS

- A. Provide one set of seals for each type and model of pump provided on the project.

PART 2. PRODUCTS

2.1. AUTOMATIC GLYCOL MAKEUP SYSTEM

- A. Furnish an automatic glycol feeder to provide consistent operating pressure in the closed loop system by feeding a controlled percentage of glycol solution. Glycol shall be made-up automatically from a pre-mixed solution tank. A low level switch shall prevent pump operation when solution level is too low.
- B. The glycol feeder package to consist of a prewired control unit in a NEMA 1 steel enclosure and a pre-piped flow assembly including a pressure switch, pressure relief valve, 50 gallon polyethylene tank, low level switch, positive displacement pump, and pressure gauges. Automatic glycol feed system shall be Pulsafeeder Model GF-1, or approved equal.
- C. Glycol solution tank shall be 50 gallons polyethylene tank with steel supports for mounting the transfer pump below the tank. Provide hinged polyethylene cover, pump suction connection, and drain valve.
- D. Positive displacement flooded suction pump rated at capacity as scheduled on the contract drawings.
- E. Provide PVC piping from the tank to the pump with PVC ball valve and steel strainer. Include at discharge a check valve, ball type shutoff valve and pressure relief valve piped

back to the solution tank.

- F. Provide a dolly suitable for transporting 55 gallon drums to the charging station. Dollies shall be suitable for storing a drum in the horizontal position so that the solution may be drained into a transfer pail. Include spring loaded draw valve.
- G. Provide 5 gallon plastic pail.

2.2. INDUSTRIAL INHIBITED PROPYLENE GLYCOL

- A. Provide a 30 percent by volume (as installed) industrial grade inhibited propylene glycol heat transfer fluid as manufactured by the Dow Chemical Company (Dowfrost HD), Houghton, Interstate Chemical (Intercool P-300) Glycochill Plus or approved equal. The 30 percent solution shall provide freeze protection to 12 degrees F and burst protection to—20 degrees F. The propylene glycol solution as supplied by the manufacturer shall contain corrosion inhibitors specially formulated for cool storage services to keep internal surfaces free from corrosion and fouling and shall include buffers, reserve alkalinity agents, antifoaming additives, and a fluorescent dye to aid in leak detection. The solution shall be easily re-inhibited using specially formulated inhibitor readily available from the field manufacturer. The manufacturer shall provide free propylene glycol yearly solution laboratory analysis. The analysis shall accurately report propylene glycol concentration, freeze point temperature, inhibitor level, alkalinity, particulate and recommended additions of glycol, inhibitor and buffers to ensure twenty-year minimum life. The fluid shall pass the ASTM D-1384 test with less than 0.5 mils penetration per year.
- B. Automotive antifreeze or any solutions containing silicates shall not be acceptable.
- C. Propylene glycol shall be supplied preduilted with deionized water and installed in the specified piping systems.
- D. Provide a Misco Products calibrated hand held refractor meter.
- E. Provide one spare 55 gallon drum of glycol.
- F. Contractor shall chemically clean and flush the completed propylene glycol system. As a minimum, system shall be cleaned with a 1 percent to 2 percent solution of trisodium phosphate in water. Provide temporary bypasses at the ice storage modules for the initial pressure testing, cleaning and flushing operations. This prevents the transfer of contaminants to the clean tubing in the modules. The system shall be thoroughly flushed using clean water and circulated for a minimum of 72 hours at which time water samples shall be taken by the contractor who shall certify that the system is free of particulate, mil scale, weld scale, solder flux, rust, metal filings, oil, grease, chlorides, sulphates, silicates and other foreign matter that could degrade the propylene glycol. After the system is charged with the approved heat transfer fluid, air shall be eliminated from the system, and the heat transfer fluid shall be circulated for 72 hours through all components. The contractor shall test and adjust the concentration to achieve 30 percent by volume propylene glycol.
- G. Entire system shall conform to EPRI Standard propylene glycol systems 15751.
- H. Flushing period (72 hours) shall be closely monitored to prevent excess heat build-up due

to pump heat.

2.3. GLYCOL FEEDER PRESSURE TANK

- A. Provide and install glycol feeder pressure tanks of size, capacity and as indicated on contract drawings. Glycol feeder pressure tanks shall be Therm-X-TROL as manufactured by AMTROL Inc., Flexcon, Wessels, Taco or approved equal. Mount tank as detailed on the drawings.
- B. Glycol feeder pressure tanks shall be specifically designed for use in glycol systems. Tanks shall be pre-charged to require pressure at the factory. The maximum working pressure shall be 150 psig. The maximum operating temperature shall be 200 degrees F. Expansion tanks shall contain removable FDA approved butyl bladder.
- C. Before installation, Contractor shall adjust the tank air pre-charge pressures to equal glycol feed pump pressure.
- D. The tank must be constructed in accordance with Section VIII of the A.S.M.E. boiler and pressure vessel code and stamped 150 psig working pressure.
- E. Accessories: Pressure gauge and air charging fitting, tank drain, pre-charge as indicated on contract drawings and factory installed clip angles.

2.4. FANS

- A. General
 - 1. Provide fans as indicated on the drawings. All fans shall have been tested and their performance rated in accordance with Air Movement and Control Association, Inc., Bulletin 210-85 Test Code and shall be licensed to bear the AMCA Seal. All fans shall carry the AMCA Certified Rating Seal for air and sound. Sound power levels shall be submitted for approval. Fan curves shall be submitted with all fan shop drawings.
 - 2. Fan manufacturer shall submit under what duct configuration (unducted, partially ducted, or ducted) the manufacturer certified the performance of a particular fan or group of fans.
 - 3. When indicated on Contract Drawings provide inverter duty rated motors for all variable speed fans.
- B. In-Line Centrifugal Fans
 - 1. Belt Drive
 - a. Furnish and install in-line centrifugal belt drive fans of the size, capacity and electrical characteristics as shown on contract drawings.
 - b. Duct mounted fans shall be of the centrifugal belt driven in-line type. The fan housing shall be of the square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars.
 - c. Fan construction shall include two removable access panels located

perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components. All in-line fans shall be factory insulated. The housing interior shall be insulated with 1-inch acoustical insulation.

- d. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
- e. Motors shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. Motors and drives shall be mounted out of the airstream. Motors shall be readily accessible for maintenance. Motors shall be high efficiency type.
- f. Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed.
- g. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
- h. Motor pulleys shall be adjustable for final system balancing.
- i. All fans shall bear the AMCA Certified Ratings Seal for both sound and air performance.
- j. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.
- k. Explosion proof fans shall be provided with explosion proof motor and non-sparking explosion proof wheel construction.
- l. Fans shall be Model BSQ as manufactured by Greenheck Fan Corporation, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

C. Power Roof Ventilators

1. Belt Drive

- a. Furnish and install belt driven power roof ventilators of the size, capacity, and electrical characteristics as shown on contract drawings.
- b. Roof fans shall be centrifugal belt driven type.
- c. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
- d. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. The fan shroud shall have a rolled bead for added strength.
- e. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motor and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Motors shall be two (2) speed type where

- indicted on drawings.
- f. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.
- g. Precision ground and polished fan shaft shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulley shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing.
- h. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A fan conduit chase shall be provided through the curb cap to the motor compartment for ease of installation.
- i. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.
- j. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.
- k. Provide 12-inch high, fully insulated, aluminum roof curbs with each ventilator. Fan and roof curb shall be provided by the same manufacturer.
- l. Provide 2-inch aluminum birdscreen with each fan.
- m. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor.
- n. Fans shall be Model GB as manufactured by Greenheck Fan Corporation, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

D. Sidewall Propeller Fans

1. Belt drive

- a. Furnish and install belt driven propeller fans of size, capacity and electrical characteristics as shown on contract drawings.
- b. All sidewall fans shall be belt driven axial type.
- c. Propellers shall be constructed with die formed galvanized steel blades riveted to a steel hub. Propellers shall be statically and dynamically balanced.
- d. Motors shall be of heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Two speed motors shall be furnished where indicated.
- e. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Propellers shall be attached to fan shafts with a standard square key and set screws or tapered bushings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speeds. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor sheaves shall be adjustable for final system balancing.
- f. Drive frame assemblies shall be formed galvanized steel construction. Fan

- panels shall have prepunched mounting holes, formed flanges with welded corners and a deep formed inlet venturi.
- g. The axial exhaust or supply fans shall bear the AMCA Certified Ratings Seals for both air and sound performance.
 - h. All steel parts shall be protected with thermally fused polyester urethane. Fan shafts shall be coated with a zinc phosphate corrosion resistant coating.
 - i. Fans shall be provided with OSHA Safety Guard. Supply fans shall be of the reverse flow configuration. Provide wall mount collars, and 2-inch aluminum birdscreen with each fan as indicated on contract drawings. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor.
 - j. Fans shall be Model SBE for exhaust and SBS for supply as manufactured by Greenheck, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

E. Power Roof Ventilators

1. Belt Drive

- a. Furnish and install belt driven power roof ventilators of the size, capacity, and electrical characteristics as shown on contract drawings.
- b. Roof fans shall be centrifugal belt driven type.
- c. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
- d. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. The fan shroud shall have a rolled bead for added strength.
- e. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motor and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Motors shall be two (2) speed type where indicated on drawings.
- f. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.
- g. Precision ground and polished fan shaft shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulley shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing.
- h. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A fan conduit chase shall be provided through the curb cap to the motor compartment for ease of installation.
- i. All fans shall bear the AMCA Certified Ratings Seal for sound and air

- performance.
- j. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.
- k. Provide 12-inch high, fully insulated, aluminum roof curbs with each ventilator. Fan and roof curb shall be provided by the same manufacturer.
- l. Provide 2-inch aluminum birdscreen with each fan.
- m. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor.
- n. Fans shall be Model GB as manufactured by Greenheck Fan Corporation, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

2.5. IN-LINE CIRCULATING PUMPS

- A. Furnish and install in-line circulating pumps as shown on the contract drawings. Pump and motor shall be equipped with sleeve bearings for quiet operation. Pumps shall be suitable for up to 175 psi working pressure and up to 300 degrees F water temperature as per ASA B16.1. Pump rating curves shall be the result of testing and rating in accordance with the procedures of the Hydraulic Institute.
- B. Pump motors shall be non-overloading throughout the range of the curves. Pumps shall have center-line discharge for positive venting, flanged bodies, and same size suction and discharge. Pumps shall incorporate a disc type lubrication system and be so designed that the bearing assembly can be removed in one piece. One bearing assembly shall be suitable for all sizes of the inline pumps furnished. Sump oil temperature may not exceed 180 degrees F when circulating 250 degrees F water with a 90 degree F ambient. Vent and drain openings at least 3 square inches in area and a water slinger shall be provided between the mechanical seal and bearing area. This water slinger shall be integral with shaft sleeve. All in-line circulating pumps shall be provided with all bronze construction when used in open system and shall be bronze fitted for closed system.
- C. Provide gauge tappings on each pump flange.
- D. Pump body shall be cast iron and pump shafts shall be alloy steel with cupro-nickel sleeve covering all wetted parts, and be coupled to the motor shaft by a noiseless non-metallic coupler. Impellers shall be one piece cast bronze, dynamically balanced. Pumps shall have a two piece mechanical seal assembly easily replaceable without the use of special tools. Motors shall be resilient mounted, 1750 RPM, and require no external overload protection when used with single phase current.
- E. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.
- F. In line pumps shall be Red Baron Series 110 in-line circulators or 1600 Series, as manufactured by Taco, Bell & Gossett, Thrush, Armstrong, Patterson, or as approved equal.

2.6. IN-LINE CLOSE COUPLED CIRCULATING PUMP

- A. Furnish and install in-line closed coupled circulating pumps as shown on the contract drawings. Pump and motor shall be equipped with permanently lubricated bearings for quiet operation. Pumps shall be suitable for up to 150 psi working pressure and up to 225 degrees F water temperature as per ASA B16.1. Pump rating curves shall be the result of testing and rating in accordance with the procedures of the Hydraulic Institute.
- B. The pumps shall be of the horizontal, permanently lubricated type, specifically designed and guaranteed for quiet operation.
- C. Provide gauge tapings on each pump flange.
- D. The pumps shall have a steel shaft supported by permanently lubricated, sealed precision ball bearings. The pumps are to be equipped with a water-tight seal to prevent leakage. Mechanical seal faces to be carbon on silicon carbide. The motor shall be non-overloading at any point on the pump performance curve.
- E. The motor shall be of the drip-proof, sealed precision ball-bearing, quiet-operating construction. The permanent split-capacitor motor shall be equipped with thermal overload protection.
- F. Pumps to be suitable for 0 degrees to 225 degrees F (107 degrees C) operating temperature at 150 psig (10 bar) working pressure.
- G. Pumps shall be provided with all bronze construction when used in open systems and shall be bronze fitted for closed systems.
- H. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.
- I. In line pumps shall be close coupled in-line circulators Model PL as manufactured by Bell & Gossett, Thrush, Armstrong, Taco, Patterson, or as approved equal.

2.7. VERTICAL IN-LINE PUMPS

- A. Furnish and install vertical centrifugal in-line single stage pump(s), with capacities and characteristics as shown on the plans. Pumps shall be Taco Model VI, Bell and gossett, Thrush, Patterson, Armstrong or approved equal.
- B. Pump volute or casing shall be constructed of class 35 cast iron. The pump shall be fitted with replaceable bronze wear rings, drilled and tapped for gauge ports at both the suction and discharge flanges and for drain port at the bottom of the casing. The pump shall be capable of being serviced without disturbing system piping. Pumps shall be bronze fitted for use in closed systems and all bronze construction in open systems.
- C. The impeller shall be bronze and hydraulically balanced by either back vanes or back wear ring and balancing holes. The impeller shall be dynamically balanced and shall be fitted to the shaft with a key.
- D. The pump shall be close coupled to a NEMA standard JM regreasble high efficiency motor. The pump shall incorporate a dry shaft design to prevent the circulating fluid from

contacting the shaft. The shaft shall be covered with a replaceable bronze shaft sleeve. Motors shall be 1750 rpm. Pumps shall be designed so that they shall not overload at low heads and shall not develop excessive pressure under throttled flow conditions or overload motor anywhere on the pump curve.

- E. The pump shall have a factory installed seal flushing line running from the seal area to the pump suction to insure removal of trapped air from the seal area, removal of sediment and cooling of the seal to extend seal life. Provide and install Cuno 5 micron filters in seal flushing line.
- F. The pump seal shall be EPT Ceramic rated to 250 degrees F. Pumps shall be finished in a baked enamel finish designed to resist rusting. Pumps shall be suitable for up to 175 psi working pressure and up to 250 degrees F water temperature.
- G. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

2.8. VARIABLE SPEED DRIVES

- A. Provide variable speed drive controllers for pumps as indicated on contract drawings.
- B. ERV variable speed drives shall be factory furnished by ERV unit manufacturer.
- C. The adjustable frequency controller (AFC) shall convert three phase 60 Hertz utility power to adjustable voltage and frequency, three phase, AC power for stepless motor control from 5 percent to 110 percent of base speed.
- D. The AFC shall be a voltage source type with a PWM output utilizing power transistor semi-conductors.
- E. The AFC together with all options and modifications shall mount within a standard NEMA 1 enclosure suitable for continuous operation at ambient temperature of 0 to 40 degrees C. with relative humidity to 95 percent non-condensing. All high voltage components within enclosure shall be isolated with steel covers. The complete unit shall be UL approved and UL labeled.
- F. Circuits shall provide DV/DT and DI/DT protection for semi-conductors. AFC shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip (IET) should any of the following faults occur:
 - 1. Motor overload.
 - 2. Shortcircuit.
 - 3. Motor overtemperature fault.
 - 4. Reverse phase.
 - 5. 110 percent of controller maximum sine wave current rating is exceeded.
 - 6. Output phase to phase and phase to ground short circuit condition.

7. High input line voltage.
 8. Low input line voltage.
 9. Loss of input phase.
 10. External fault. This protective circuit shall permit, by means of the terminal strip, wiring of remote NC safety contacts such as high static, firestat, etc., to shut down the drive.
- G. The following adjustments shall be available in the controller and retained in non-volatile memory:
1. Maximum frequency (15 to 400 Hz) factory set at 60 Hz.
 2. Minimum frequency (3 to 60 Hz) factory set at 6 Hz.
 3. Acceleration (.1 to 360 seconds) factory set at 20 seconds.
 4. Deceleration (.1 to 360 seconds) factory set at 20 seconds.
 5. Volts/Hertz ratio factory set for 460V at 60 Hz.
 6. Voltage offset or boost factory set at 100 percent torque.
 7. Current limit (50 percent to 110 percent sine wave current rating) factory set at 100 percent current.
- H. The AFC shall have the following basic features:
1. Door-mounted operators controls consisting of a membrane command center which allows manual stop/start and speed control, local/remote indication and manual/or automatic speed control selection. In addition, the command center shall serve as a means to configure controller parameters such as min speed, max speed, acceleration and deceleration times, Volts/Hz ratio, torque boost etc. Potentiometers shall not be allowed for these settings.
 2. Main input disconnect to provide a positive disconnect between the controller and all phases of the incoming A-C line. This disconnect shall be mounted inside the controller enclosure and have through-the-door interlocking toggle with provisions for padlocking.
 3. Electronic motor overload relay.
 4. Automatic restart after power outage, drive fault or external fault, with drive in automatic mode. The circuit shall allow the user to select up to (10) restart attempts as well as the dwell time between attempts. The reset time between fault occurrences shall also be selectable. All settings shall be via the membrane command center.
 5. Door-mounted LED display for digital indication of:

- a. Frequency output
 - b. Voltage output
 - c. Current output
 - d. First fault indication
 - e. Fan or Pump Speed (RPM)
6. Relay contacts for remote indication of drive fault and motor finning.
7. Three critical frequency avoidance bands, field programmable via the membrane command center. Each critical frequency avoidance band shall have a bandwidth adjustable via keypad entry of up to 10 Hz.
8. Three programmable preset speeds which shall force the AFC to a preset speed upon a user contract closure.
9. Isolated process follower to enable VFC to follow a 4-20 mA signal.
10. The AFC shall have the capability to ride through power dips up to 500 msec without a controller trip depending on load and operating condition.
11. Line reactor to minimize line surges, line notching, and voltage distortions. Line reactor shall be installed upstream of the drive.
- I. Manual bypass-to-line with magnetic contactors to transfer motor from the variable frequency controller to full speed operation on utility supplied input power while the motor is at any speed. Two motor contactors, electrically interlocked shall be utilized, one contactor between the controller output and the motor and the other between the bypass power line and the motor, providing across-the-line starting.
- J. Motor protection per National Electrical Code shall be provided in both the "controller" mode and the "bypass" mode by a motor overload relay. The 115 volt A-C relay control logic, allowing common start/stop commands in the "controller" mode and the "bypass" mode shall also be included within the enclosure.
- K. The bypass shall include a door interlocked, main power input circuit breaker providing positive shutdown of all power to both the bypass circuitry and the VFC. The bypass circuit shall also include a second input disconnect to the VFC. This disconnect shall provide the ability to safely trouble shoot and test the controller, both energized and de-energized, while operating the bypass mode.
- L. The VFC and all components shall be supplied within a single NEMA 1 enclosure, and shall be U.L. Listed as a single unit. Furnish all components necessary to provide a minimum lead length between motor and drive of 400 ft. The VFC shall not generate damaging transistor pulses greater than the limits set by NEMA MG-1 at 400 Ft lead length.
- M. The VFC manufacturer shall maintain and staff nationwide service centers. These service engineers shall be employed by the manufacturer and provide start-up service including physical inspection of drive and connecting wiring and final adjustments to meet specified performance requirements.
- N. The VFC shall carry a full parts and labor warranty for two years from date of Owner

acceptance of the building.

- O. The variable speed drive shall be ABB, or approved equal of Accutrol, Cutler Hammer, Graham, York, Baldor, AC Tech, Trane, Emerson, Danfos, Yaskawa, Toshiba, or as approved equal.
- P. The variable speed drive manufacturer shall coordinate with the ATC contractor and provide all necessary devices whether optional or not to perform complete and automatic operation as described in the sequence of operation. All safeties, including freezestats, duct smoke detectors, and high static pressure sensors shall be enabled when variable speed drives are in manual or bypass.
- Q. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.
 - 1. Network Communications Ports: Ethernet and RS-422/485.
 - 2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.
- R. Variable speed drives shall be carefully selected for the duty required. Variable speed drives shall be specifically designed for the specified equipment to be controlled. Pump drives shall be selected for pumps and fan drives shall be selected for fans.

2.9. COMBINATION COALESCING AIR AND DIRT SEPARATOR

- A. Furnish and install as shown on the drawings a Spirotherm steel, Taco Series 4900, Caleffi, Armstrong, Wessels, or approved equal air elimination and dirt separator. All fittings shall be fabricated steel, rated for 150 psig design pressure and selected for less than 1 foot of water pressure drop and velocity not to exceed 4 feet per second through the unit at specified GPM. All units shall include an integral copper bundle of Spirotubes or approved equal, to act as the turbulence suppressive coalescing medium which must completely fill the fitting's internal area. Units are to remove free and entrained air during system start up and continue to eliminate dissolved air and dirt through continual circulation and the coalescing action of the Spirotubes. Each fitting is to have a separate air and venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral float actuated brass air vent. There shall be no restriction in the connection from the venting chamber to the vent. The fittings are to include a valve side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Units shall include a bottom connection for use as a blow down connection for periodic cleaning. Unit shall have the bottom of the vessel extended for dirt separation with the system connection nozzles equal distant from the top and bottom of the vessel. Air separator shall be primed and finished in rust resistant paint. Units shall be Spirovent dirt models of the size required to meet pressure drop and velocity criteria.
- B. A blowdown connection and valve shall be provided to facilitate routine cleaning of the strainer and the separator. Unit shall include a removable lower head to facilitate removal of the tube assembly for cleaning.

- C. A manufacturer's data report for pressure vessels, for U-1 as required by the provisions of ASME Boiler and Pressure Vessel code, shall be furnished for each air separator upon request. Manufacturer to furnish data sheet specifying air collection efficiency and pressure drop at rated flow.
- D. Conventional tangential or centrifugal non-coalescing air separators shall not be acceptable.

2.10. EXPANSION TANKS

- A. Furnish and install as shown on the drawings, pre-pressurized captive air bladder type expansion tank pre-charged with air. Tank shall be suitable for a maximum working pressure of 125 psi and constructed and certified to ASME Section VII. It shall have a replaceable elastomeric bladder suitable for a maximum operating temperature of 240 degrees F (115 degrees C). Expansion tanks shall be primed and finished in rust resistant paint. It shall have an integral steel base ring for vertical mounting and saddle for horizontal mounting. Expansion tank shall be as manufactured by Taco, Bell & Gossett, Wessels, Amtrol, Armstrong or as approved equal.

2.11. HORIZONTAL RECESSED CABINET UNIT HEATERS(WITH INTEGRAL SUPPLY/RETURN GRILLES)

- A. Furnish and install horizontal recessed cabinet unit heaters of the size, capacity, and electrical characteristics shown on the contract drawings. Units shall be Trane, Model E, Dunham Bush, Modine, Rittling, or approved equal.
- B. Cabinet is galvanized steel wrap-around structural frame with all edges flanged. Insulation is faced, heavy density glass fiber. Unit to have 18 gauge steel, removable, four-side overlap bottom panel adjustable 3/8 inch with full length, piano type hinge at back and camlocks at front. All cabinet parts shall be finished in a baked on enamel finish in color as selected by Architect. Bottom panels on horizontal recessed units shall be provided with tamper-proof screw fasteners and safety chain.
- C. Water coils to be 5/8 inch OD seamless copper tubes mechanically bonded to configured aluminum fins with continuous fin collars and sleeved coil end supports. Maximum working pressure 300 psig, factory test pressure 450 psig (air). Supply and return connections on same side of units.
- D. Fans shall be centrifugal, forward curved, double width of non-corrosive, molded, fiberglass-reinforced thermo-plastic materials. Fan wheels and housings shall be corrosion resistant.
- E. Motor shall have integral thermal overload protection and start at 78 percent of rated voltage. Motor to be factory installed and tested prior to shipping.
- F. Filters to be accessed by pivoting hinged bottom panel. Filters shall be 1 inch woven glass filters.
- G. Provide each unit with factory furnished bottom integral grilles for supply and return. Unit shall be provided with factory furnished vibration isolators and mounted in an approved manner with all threaded steel rod.

- H. Provide 18 gauge steel flanges (factory furnished) for recessing unit heater into ceiling.
- I. Unit shall be U.L. listed.

2.12. HORIZONTAL HOT WATER UNIT HEATERS

- A. Provide and install horizontal hot water unit heaters of the size, capacity and electrical characteristics as indicated on the contract drawings. Horizontal unit heaters shall be Trane Model S, Dunham Bush, Modine, or approved equal.
- B. Casing shall be two-piece with "picture frame" front formed into wrap around sides, top and bottom. Furnish each unit with louvered fin diffuser for versatility in lateral diffusion. Casing shall be 18 gauge back panel with deep-drain fan orifice for extreme rigidity. Steel supply and return pipe top connectors bolted to back. Casings phosphatized to prevent corrosion and finished with a green baked enamel finish.
- C. Fan shall be high efficiency Model A with aluminum blades, factory balanced and sturdy for standard applications.
- D. Coils shall be hot water, single tube single serpentine design. Fins shall be aluminum sigma-flow, mechanically bonded to seamless copper tubing. All coils one-row deep in air flow direction. Coils shall be tested at 300 psig air under water. Coils shall be suitable for operation at 200 psig or 325 degrees F.
- E. Motors shall be totally enclosed, class "B" insulated shaded pole and permanent split capacitor. All motors shall have built-in overload protection. Sleeve bearing motors can be oiled. Ball bearing motors are permanently lubricated. Units shall be U.L. listed.

2.13. EXTERIOR EQUIPMENT/DUCT SUPPORT

- A. Exterior Equipment Supports shall be Pate Model ES suitable for roof construction. Equipment supports shall be constructed of 18 gauge galvanized steel, unitized construction with integral base plate, continuous welded corner seams, pressure treated wood nailer counterflashing and lag screws. Units shall be internally reinforced. Minimum height shall be 12-inches above the finished roof or as shown on the detail(s) on the drawing(s).

2.14. EXTERIOR PIPE ROLLER SUPPORTS

- A. Furnish and install pipe roller supports for all exterior piping as indicated on contract drawings. Pipe roller supports shall be constructed of heavy gauge galvanized steel, continuous welded corner seams, 2 x 4 treated wood nailer, heavy gauge galvanized steel counterflashing with galvanized steel channel track attached.
- B. Roller assembly shall consist of galvanized steel channel track, galvanized steel fittings, washers, nuts, and painted cast iron roller. Installation shall permit both vertical and horizontal adjustment. Units shall be Pate Model RAC or approved equal.

2.15. ROOF CURBS (DUCT PENETRATIONS)

- A. Furnish and install roof curbs at all penetrations of roof by ductwork and where indicated

on contract drawings. Roof curbs shall be Model PC as manufactured by Pate, Greenheck, or approved equal.

- B. Roof curbs shall be constructed of heavy gauge galvanized steel, unitized, full material corners, all seams welded, 1 ½ -inch thick rigid fiberglass insulation, pressure treated wood nailer strip. Curbs shall be minimum 12-inch height unless otherwise noted and have inner diameter equal to indicated duct diameter.

2.16. EXTERIOR ROOFTOP PIPING SUPPORT (NON-PENETRATING)

- A. Exterior Piping Supports shall be non-penetrating roof piping supports suitable for roof construction as manufactured by RTS – Rooftop Support Systems, Eberl, Iron Works, Inc. Pipe supports shall be constructed of 18 gauge stainless steel, unitized construction with integral base plate. Units shall be internally reinforced. Minimum height shall be 12-inches above the finished roof or as shown on the detail(s) on the drawing(s). Provide all stainless steel hardware. Duct support shall be “double support” type with adjustable height and width. Base shall be non-penetrating type, heavy duty rubber, manufactured from 100% recycled crumb rubber.

2.17. AIR MONITORING STATIONS (ERV UNITS)

- A. General: Provide complete air monitoring station for ERV units as indicated on drawings. The air monitoring station shall include airflow measuring stations, static pressure probes and electronic velocity pressure transmitter. All components shall be of the same manufacturer. The manufacturer shall be Air Monitor, Gold Series Ebtron Thermistar, or as approved equal. An air monitor station shall be provided for each supply duct main, exhaust duct main, and return duct main as indicated on contract drawings. All air flow monitoring stations shall be fully externally insulated to prevent condensation.
- B. Air Monitor Airflow Measuring Stations
 1. Provide where indicated, airflow measuring stations capable of continuously monitoring the fan or duct capacities (air volumes) they serve.
 2. Each airflow measuring station shall contain multiple total and static pressure sensors positioned at the center of equal area of the station cross-section and interconnected by their respective averaging manifolds. For stations of 4 square feet or less, one total and one static pressure sensor shall be present for every 16 square inches of station area respectively. For stations of larger area, one total and one static pressure sensor shall be present for every 36 square inches of station area respectively.
 3. The airflow measuring station shall be fabricated of a minimum of 14 ga. galvanized steel, welded casing in 8-inch depth with 90 degree connecting flanges in a configuration and size equal to that of the duct it is to be mounted into. Each station shall be complete with an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to the casing, total and static pressure sensors located on an equal area basis and connected to symmetrical averaging manifolds, internal piping, and external pressure transmitter ports. An identification label shall be placed on each station casing listing model number, size, area, and specified airflow capacity.

4. Cell construction shall be 3/8-inch .003-inch, type 3003 aluminum, expanded.
5. The maximum allowable pressure loss through the station shall not exceed .015-inch wc at 1000 fpm, or .085-inch wc at 2000 fpm. Each station shall be capable of measuring the airflow rate within an accuracy of 2 percent as determined by U.S.G.S.A. certification tests. The stations shall have a self-generated sound rating of less than NC 40, and the sound level within the duct shall not be amplified, nor shall additional sound be generated.
6. Stations shall be Fan-E type as manufactured by Air Monitor Corporation, Paragon or as approved equal.

C. Air Monitor Duct Static Pressure Traverse Probes

1. Provide where indicated duct static traverse probe capable of continuously monitoring the duct or system static pressure it serves.
2. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Said sensors shall not protrude beyond the surface of the probe.
3. The duct static traverse probe shall be of extruded aluminum construction and (except for 3/4-inch diameter probes with lengths of 24-inches or less) be complete with threaded end support rod, sealing washer and nut and mounting plate with gasket and static pressure signal fitting.
4. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure, without need for correction factors, with an instrument accuracy of 0.5 percent.
5. The duct static pressure traverse probe shall be the STAT-probe/1 as manufactured by the Air Monitor Corporation, Paragon or as approved equal.

D. Air Monitor Electronic Velocity Pressure Transmitters

1. The electronic control-instrument components shall be of industrial process control quality with operating features described herein and capable of producing the outlined performances. Commercial grade control-instruments, devices, are not acceptable.
2. The electronic differential pressure transmitter shall include an automatic zeroing circuit capable of automatically readjusting the transmitter zero at predetermined (adjustable) time intervals while retaining (locking in) the output signal. The electronic differential pressure transmitter shall be capable of receiving signals of duct total and static pressures, and of amplifying and scaling the sensed differential pressure into a 4-20 mADC or 0-5 (0-10) VDC output signal linear to differential pressure, within the following minimum performance criteria:

Zeroing	Automatic, within 0.1 percent of operating span, on 4 to 256 minute intervals (selectable)
---------	--

Spans	Factory custom spanned, coordinated with system, ranges from 0 to .01-inch to 0 to 10.0-inches. Field adjustment +20 percent of span.
Accuracy	+ 0.25 percent of span
DeadBand and Hysteresis (Combined):	Less than 0.2 percent of span
Linearity:	+ 0.2 percent of span
Repeatability:	0.15 percent of span
Response:	0.5 second for 98 percent full span input
Power Supply:	24 VAC, 20 to 40 VDC, selectable; 4 wire

3. Coordinate requirements with the buildings direct digital control system to perform the required sequence of operation.
4. The pressure transmitter shall be the VELTRON series 5000AZ as manufactured by the Air Monitor Corporation, Paragon, Greenheck, Johnson Controls, or as approved equal.

2.18. WATER TREATMENT SERVICES

- A. Complete chemical water treatment service shall be provided by an organization regularly engaged in water treatment, ARC, Inc., RCCO Corp., Aquatel Ind., Inc., Mogul Corp., Oilin, Inc., HVAC Services, Inc., Feedwater Treatment Systems, Inc., Eco-Lab, or approved equal. The service shall provide all equipment, chemicals and labor necessary to prevent corrosion, inhibit scale build-up and minimize organic growth for a period of 2 years starting from building acceptance. Service visits for the purpose of adding chemicals to feeding equipment, regulating bleed-off, inspecting and adjusting water treatment equipment, and obtaining samples of laboratory analysis shall be performed at monthly intervals for closed systems and every two weeks for open systems during the entire guarantee period. Chemicals shall not be injurious to water side equipment and construction materials. Records of all injurious to water side equipment and construction materials. Records of all service visits, chemical additions, laboratory tests, etc., shall be maintained and shall be provided to owner after each visit during guarantee period. Instruct mechanical contractor in field on piping and wiring of chemical feeding equipment.
- B. Systems to be protected shall include glycol systems and hot water heating system. Services shall include flushing and cleaning of piping systems specified under Division 23 Section, "HVAC Piping, Fittings, and Valves" section, furnishing and installing all chemical treatment equipment and accessories to perform the water treatment specified below. Maintain complete records of the treatment program for each system.
- C. Contractor shall perform an analysis of the building water supply as a basis of the chemical treatment. Contractor shall provide the Owner with written instructions for chemical feeding bleed-off, blowdown control and testing procedures, provide all required chemicals

during the guarantee period, and provide all required test kits.

D. Contractor shall maintain the following conditions in each system:

SYSTEMS	Hot Water System
ph	7.0 to 10.0
Inhibitor for Scale & Corrosion Cycles	---
Cycles*	---
Organic	---
Buffered Nitrate	1000 ppm to 180 degrees F 2000 ppm to 180 degrees F
Chromate (Low)	
Molybdate	50 to 100 ppm
Sulfite	---
Sodium Nitrite	1000 to 1500 PPM
Corrosion Inhibitor	
*Actual cycles of concentration to be determined from analysis of make-up water.	
Use Inhibited Glycol supplied by Manufacturer.	

E. Chemical Feeding Equipment: Provide chemical feeding equipment, as specified below, to introduce chemicals into each system only when the system is operating.

1. Closed Recirculating Systems

a. Five (5) gallon steel by-pass feeder installed across circulating pump suction and discharge lines, with tank and piping insulated using the same thickness and type of insulation as provided for the piping system. Provide filter. Unit shall contain quick opening cap and shall be suitable for working pressure of 175 psig. Tank shall be primed and finished in baked enamel paint.

2. Replace bypass feeder filter monthly during the entire 2-year warranty period.

F. Boilers shall be boiled out with an alkaline type boiling out compound to remove grease,

oil, mill scale and other foreign matter. The compound should be used at the rate of 1-1/2 pounds per 20 boiler horsepower. After boiling out period, the boilers should be completely drained, flushed, refilled with fresh water and vented. All water treatment chemicals shall comply with Delaware Water Resources laws and regulations.

- G. Closed Recirculating Systems shall be filled and sufficient detergent and dispersant added to remove all dirt, oil, and grease. System shall be circulated for at least 48 hours after which a drain valve at the lowest point shall be opened and allowed to bleed while the system continues to circulate. The automatic make-up valve shall be checked to be sure it is operating. Bleeding shall continue until water runs clear and all detergent is removed. A sample of water shall be tested and if PH exceeds the PH of the make-up water, flushing shall be resumed.
- H. Where glycol is specified or used, additional corrosion inhibitors should not be added without consulting the glycol manufacturer. The boilers shall be fired, maintaining a slow, rolling boil and preventing steam pressure from building during the process, while the surface of the water is continuously skimmed to remove impurities, the boiler manufacturer's recommended procedure shall be followed.

2.19. ENERGY RECOVERY VENTILATORS

- A. Provide and install ERV's (Energy Recovery Ventilators) as shown on contract drawings. ERV's shall be Model ERCH as manufactured by Greenheck, Aeon, Venmar, Valent, or approved equal.
 - 1. Energy Recovery Ventilator shall be as manufactured by Greenheck or approved equal provided all specifications are met. Greenheck Model ERCH equipment is used as the basis of design. Units shall be listed per UL 1812 and bear the UL label. Energy transfer ratings shall be in accordance with ASHRAE Standard 84 and ARI 1060. Wheels shall be ARI 1060 certified. Performance to be as scheduled on plans. Exhaust discharge and outside air intake shall not be located on the same side on rooftop units.
 - 2. Unit shall be of internal frame type construction of galvanized steel. All frame and panel shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces shall be sealed, requiring no caulking at job site. Unit base to be designed for roof mounting.
 - 3. Unit casing to be insulated with 1 in - 3 lb. fiber-glass with Foil-Scrim-Kraft facing. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit with water proof adhesive and permanent mechanical fasteners.
 - 4. Wheel shall be of the enthalpy type for both sensible and latent heat recovery and be designed to insure laminar flow. Efficiency ratings shall be based on tests conducted in accordance with ASHRAE 84 and laminar flow. Efficiency ratings shall be based on tests conducted in accordance with ASHRAE 84 and ARI 1060 standards. Desiccant shall be silica gel for maximum a latent energy transfer. Wheel shall be constructed of light weight polymer or aluminum media to minimize shaft and bearing loads. Polymer or aluminum media shall be mounted

in a stainless steel rotor for corrosion resistance. Wheel design shall consist of removable segments for ease of service and/or cleaning. Segments shall be removable without the use of tools. Silica gel desiccant shall be permanently bonded to wheel media to retain latent heat capability after cleaning. Energy recovery device shall transfer moisture entirely in the vapor phase.

5. All components shall be easily accessible through removable hinged doors for both exhaust fan, supply fan, filter and damper compartments. Energy recovery wheels (smaller than 54 in.) shall be mounted in a slide-out track for ease of inspection, removal and cleaning.
6. Refer to Division 23 Section, "Common Work Results for HVAC" for VFD motor bearing protective rings.

B. Fans

1. Centrifugal blowers shall be backward inclined and housed in a scroll to maximize fan efficiency. Fans shall be AMCA certified for air performance. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently sealed ball bearing pillow blocks. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds. Blowers shall enable independent balancing of exhaust and supply airflow with adjustable sheaves for motors 10 horse power and below. Fans shall be located in draw-through position in reference to the energy recovery wheel.
2. Motors shall be inverter duty energy efficient, complying with EPACT standards, for variable speed ODP and TE enclosures. Motors shall be permanently lubricated, heavy duty type, matched to the fan load and furnished at the specified voltage, phase and enclosure. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be fully machined cast. Energy wheel motors shall have integral overload protection.
3. All internal electrical components shall be pre-wired for single point power connection. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code. The control center shall include a weatherproof disconnected switch, motor starters, control circuit fusing, control transformer for 24 VAC circuit and motor starters. Motor starters shall consist of a contactor and Class 20 adjustable overload protection and shall be provided for all motors in the unit.
4. Energy recovery ventilators housings shall be factory primed and painted in color as selected by Architect.
5. Both the supply and exhaust air streams shall be filtered to protect the enthalpy wheel. Furnish and install 30 percent pleated filters (Farr 30/30 or approved equal), filter racks and access panels. Provide one (1) set of additional filter media to Owner for each unit.
6. Furnish exhaust and outside air intakes with hoods provided with bird screens and sound lining.

C. Direct Expansion (DX) Cooling System

1. Air-Cooled Condenser Section:

- a. The condensing section shall be equipped with vertical discharge axial flow direct drive fans. Direct drive fans shall be directly connected to and supported by the motor shaft.
- b. The condenser coils shall be sloped at least 30° to protect the coils from damage.
- c. Condenser coils shall be copper tubes with aluminum fins mechanically bonded to the tubes.
- d. Condenser coil fin design shall be sine wave rippled.
- e. Condenser coils to be sized for a minimum of 10°F of refrigerant sub-cooling.

2. Evaporator Coils:

- a. Evaporator coil shall be copper tube with aluminum fins mechanically bonded to the tubes.
- b. Evaporator coil fin design shall be sine wave rippled.
- c. Evaporator coil shall have galvanized steel end casings.
- d. Evaporator coil shall have equalizing type vertical tube headers.
- e. Evaporator coil shall be furnished with a thermostatic expansion valve.
- f. Evaporator coil shall be furnished with a double sloped drain pan for the positive drainage of condensate.
- g. Evaporator coils shall be interlaced type.

3. Refrigeration System:

- a. Compressors shall be scroll type with internal thermal overload protection and mounted on the compressor manufacturer's recommended rubber vibration isolators.
- b. Compressors shall carry a 5 year non pro-rated warranty.
- c. Each compressor shall be individually stage for capacity control. All units over 7 tons shall be multiple stage and shall have a minimum of 2 stages of capacity control.
- d. Compressors shall be mounted in an isolated compartment to permit operation of the unit without affecting air flow when the door to the compartment is open.
- e. Compressors shall be isolated from the base pan and supply air to avoid any transmission of noise from the compressor into the building area.
- f. Each refrigerant circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.
- g. Each refrigerant circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant controls. Each refrigeration circuit shall be equipped with Schrader type service fittings on both the high pressure and low pressure sides.
- h. Each refrigeration circuit shall be equipped with refrigerant liquid line driers.
- i. Unit shall be fully factory charged with R-410A refrigerant.
- j. Each compressor shall be equipped with suction and discharge

- service/isolation valves.
 - k. The first on and last off compressor shall be a digital scroll compressor and shall be capable of capacity modulation from 10-100%.
 - l. Condensing unit fans shall be ECM, variable speed type for head pressure control.
- 4. Unit shall dehumidify using a hot gas reheat coil, modulating hot gas reheat control valves piped to the lead refrigerant system, and an electronic controller. A factory-wired, field installed, supply air temperature sensor and a field-installed space humidity sensor shall be provided to control the amount of reheat. The supply air temperature set point shall be adjusted on the electronic controller within the controls compartment.
 - 5. All compressors shall be provided with a (5) five year parts and labor warranty.
 - 6. Furnish each unit with an insulated, stainless steel drain pan under the coil extending past the coil to ensure condensate retention.
- D. Hydronic Coil:
- 1. Hot water coils shall be furnished to meet the performance requirements set forth in the schedule. All coils shall have performance certified in accordance with ARI Standard 410. Coils shall be arranged in the unit for horizontal air flow and selected for a maximum face velocity as scheduled. Install coils such that headers and return bends are enclosed by unit casings.
 - 2. Coil casing shall be constructed of heavy gauge galvanized metal with aluminum die-formed corrugated fins and guide channels to create turbulent wiping behind the tubes. The fins shall have drawn collars, be belled and mechanically expanded to firmly bound the copper tubes to the fins. All coils shall be installed on tracks for easy removal from the energy recovery unit.
 - 3. Drainable water coils shall be designed to operate at 250 psig design working pressure and up to 300 degrees F and shall be tested with 325 psig compressed air under water. Circuiting shall provide free draining and venting when installed, counter flow of air and water with water velocities not to exceed seven feet per second and without exceeding the water pressure drops scheduled. All coils must have same end connections regardless of the number of rows deep. Clearly label supply and return headers on outside of units such that direction of coil water flow is counter to direction of unit airflow.
 - 4. Construct coils of configuration plate fins and seamless tubes. Fins shall have collars drawn, belled and firmly bonded to tubes by means of mechanical expansion tubes. Do not use soldering or tinning in bonding process.
 - 5. Construct coil casings of Gavanized G90-U steel with formed end supports and top and bottom channels. If two or more coils are stacked in unit, install intermediate drain channels between coils to drain condensate to main drain pans without flooding lower coils or passing condensate through air stream.
 - 6. Coil grommets shall be provided on all coils to completely seal the area between

the coil connection and the unit casing.

7. Control valves shall be furnished by ATC Subcontractor and installed by the mechanical contractor.

E. Demand Control Ventilation Components:

1. Energy recovery ventilator fans shall be controlled by a variable frequency drive. Outdoor air and exhaust air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and exhaust air volumes are always maintained. The variable frequency drive shall be factory mounted in the unit cabinet and wired.
2. Energy recovery ventilator shall be equipped with demand control ventilation capabilities that enable the varying of outdoor air and exhaust air volumes based on building occupancy. A sensor shall be located in the exhaust air stream to monitor average CO2 levels of the occupied spaces. A variable frequency drive shall receive a 0-10 volt signal from the CO2 sensor and control the outdoor air volume to maintain a maximum of 1,000 ppm of CO2 in the occupied space. Outdoor air and exhaust air fans shall be controlled simultaneously to maintain desired building pressure. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and exhaust air volumes are always maintained. The sensor and variable frequency drive shall be factory mounted and wired. Additional space CO2 sensors shall be required (refer to plans for quantity and locations) and interlocked with ERV demand controlled ventilation system.
3. Furnish each energy recovery ventilator with the following:
 - a. Supply air fan variable frequency drive.
 - b. Exhaust air fan variable frequency drive.

F. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.
2. Filters: Furnish one set of each type of filter.
3. Fan Belts: Furnish one set of belts for each belt drive fan in energy recovery ventilator.
4. Wheel Belts: Furnish one set of belts for each belt driven energy wheel.

G. Roof Curb

1. An insulated, pre-fabricated roof curb shall be provided and shipped knocked down. The roof curb will be made of 16-gauge galvanized steel with 4" flanges, minimum 14" high with a factory installed 2" x 3" wood nailer strip. Curbs shall

be fully insulated with 1 ½ inch thick rigid insulation with duct adapters.

2. Piping, ductwork, and electrical shall enter unit concealed within roof curb. All piping within the unit enclosure shall be insulated with insulation type, thickness, and jacketing as specified in Division 23 Section, HVAC Insulation.

H. Digital Precise Air Controller

1. The unit shall include a factory installed microprocessor based unit controller which controls the operation of the unit including the compressor(s), condenser fan motor(s), supply fan motor, heater, economizer, return air bypass, and modulating hot gas reheat.
2. Factory mounted and wired is an outside air temperature sensor and suction pressure transducer. Factory wired for field installation is a supply air temperature sensor. Furnished with the unit for field installation are a space air temperature sensor with temperature set point reset and unoccupied override and a space humidity sensor.
3. Controller
 - a. Controller shall be capable of independent stand alone operation and have the ability to communicate and integrate with widely-used building automation systems. Controller shall be IP addressable and be able to reside on a TCP/IP network. Controller shall have 2 RJ-45 Ethernet ports, 1 RS-232 port, and 1 RS-485 port.
 - b. Controller shall require a PC with the Greenheck configuration tool software for configuration and programming. With graphical user interface over IP option controller can be configured through a browser over the internet.
 - c. Controller shall have a full calendar schedule for occupied, unoccupied, and holiday scheduling.
 - d. Controller shall retain all programmed values in non-volatile memory in the event of a power failure.
 - e. Configuration tool software, when connected to unit controller, shall indicate unit status, set points, and faults.
 - f. With modulating hot gas reheat a field installed space humidity sensor and a field installed supply air temperature sensor will be furnished to control the amount of reheat. An electronic modulating reheat controller will also be furnished. The supply air temperature set point shall be set on the modulating reheat controller.
 - g. Furnish controls with necessary interfaces to communicate via BACNET/IP to a Building Automation System.

I. Unit Sequence of Operation

1. Refer to Division 23 Section, "Instrumentation and Controls of HVAC & Plumbing Systems".

2.20. WATER TO AIR GROUND SOURCE HEAT PUMPS (ROOFTOP UNITS)

- A. Provide water-to-air ground source rooftop heat pumps of the size, capacity, efficiency, and electrical characteristics as indicated on the Contract Drawings. Units shall be RN Series as manufactured by Aaon, Trane, McQuay, Water Furnace, Johnson Controls, Florida Heat Pump, Climate Master, or approved equal.
- B. Units shall be ARI 330 certified for use as extended range heat pumps for geothermal closed loop applications.
- C. Equipment shall be completely assembled, piped, internally wired and test operated at the factory. Units shall be both ETL and ISO-ARI 13256-1 listed and labeled prior to leaving the factory. Service and caution area labels shall be also be placed on the unit in their appropriate locations. Wiring internal to the unit shall be colored and numbered.
- D. Each unit shall be specifically designed for outdoor rooftop installation.
- E. The units shall be furnished complete with insulated casing, centrifugal fans, power relief air fan, coils as scheduled, insulated drain pan, motor, adjustable drives and accessories as required.
- F. Adequate space around all sides of the rooftop units shall be provided for proper service and maintenance.
- G. Each unit shall be completely assembled on a rigid base for one piece shipping and rigging. Each unit shall be mounted on a roof curb provided by the same manufacturer.
- H. A/C condensate drain for each unit shall be insulated stainless steel. Condensate drains shall terminate on roof.
- I. Provide N.F.P.A 90-A approved flexible duct connections on supply and return duct connections at unit.
- J. Cabinet:
 - 1. Unit casing shall be constructed of zinc coated, heavy gauge, galvanized steel. All components shall be mounted in a weather-resistant steel cabinet with a painted exterior. Service panel shall contain lifting handles that require no more than three (3) screws while providing a water and air tight seal.
 - 2. The insulation shall be 1½" inch thick dual density bonded glass fiber. The exposed side shall be a high density erosion proof material suitable for use in airstream up to 4500 feet per minute (FPM). Insulation shall meet the Underwriters Laboratories Fire Hazard Classification:
 - a. Flame Spread = 20
 - b. Fuel Contributed = 15
 - c. Smoke Developed = 0
 - 3. Access for inspection and cleaning of the unit drain pan, coils and fan section shall be provide. The unit shall be installed for proper access. Procedures for proper access inspection and cleaning of the unit shall be included in the maintenance manual.

4. Furnish units with 1 inch thick, pleated, 30 percent efficient removable filters with filter frame.
5. Filter racks shall be gasketed and air tight to prevent leakage.

K. Sound Attenuation:

1. Sound attenuation shall be applied as a standard feature in the product design.
2. The sound reduction package shall include a compressor discharge muffler, vibration isolation to the compressor and water-to-refrigerant coil, unit base stiffeners, insulated metal compressor enclosure, and a second stage of vibration isolation to the compressor and water-to-refrigerant base pan.
3. The unit shall be tested and rated in accordance with ARI 260P.
4. Furnish and install sound attenuation blankets.

L. Refrigeration System

1. The unit shall include a high efficiency, direct drive hermetic reciprocating compressor. Units 25 ton and larger shall be direct drive, hermetic, scroll type with gear type oil pump. External vibration isolation shall be provided by rubber mounting devices located underneath the mounting base of the compressor. A second isolation of the refrigeration assembly shall be supported under the compressor mounting base. Where scheduled provide multistage units.
2. Compressor motors shall contain centrifugal oil pump and shall be suction gas-cooled. Compressors shall include crank case heater, internal temperature and current-sensitive motor overloads.
3. Internal thermal overload protection shall be provided. Protection shall be provided against excessive discharge pressure operation by means of a high pressure switch. Loss of charge protection shall be provided by a low pressure switch.
4. Heat Exchanger: The water-to-refrigerant heat exchanger shall be of a high quality coil in shell type for maximum heat transfer. The cupro-nickel coil or stainless steel shall be deeply fluted to enhance heat transfer and minimize fouling and scaling. The coil shall have a working pressure of 450 psig of both the refrigerant and water sides. The factory shall provide rubber isolation to the heat exchanging device to enhance sound attenuation.
5. Reversing Valve: The reversing valve shall be a pilot operating sliding piston type with replaceable encapsulated magnetic coil. This valve shall be energized in cooling.
6. Tubing: The refrigerant tubing shall be of 99 percent pure copper. This system shall be free from contaminants and conditions such as drilling fragments, dirt and oil. All refrigerant and water lines shall be insulated with an elastomeric insulation that has a 3/8-inch thick wall wherever air is introduced to the assembly.

7. Refrigerant Metering: The equipment shall be provided with a (TXV) thermal expansion valve to allow operation of the unit with entering fluid temperature from 25 degrees Fahrenheit to 125 degrees Fahrenheit. Refrigerant circuits shall contain service pressure ports and factory installed refrigerant line filter dryer.
8. Schrader Connections: The refrigerant access ports shall be factory supplied on the high and low pressure sides for easy refrigerant pressure or temperature testing.
9. Refrigerant type shall be HFC-407C or HFC-410A.
10. All refrigerant piping and heat exchangers shall be factory insulated to minimize heat transfer and eliminate condensation.

M. Air-to-Refrigerant Coil:

1. The air-to-refrigerant coil shall contain copper tubes mechanically expanded into evenly spaced aluminum fins. All coils are to be leak tested. Pressure testing shall be performed at 450 psig operating pressure and the leak test at 125 psi operating pressure with helium. In addition, the tubes are to be completely evacuated of air prior to shipment.
2. The refrigerant coil distributor assembly shall be of orifice style with round copper distributor tubes. The tubes shall be sized consistently with the capacity of the coil. Suction headers shall be fabricated from rounded copper pipe.
3. A thermostatic expansion valve shall be factory selected and installed for a wide range of control.
4. Unit shall be factory furnished with hot gas re-heat coil with modulating hot gas re-heat valves.
5. Evaporator coil shall be interlaced type.

N. Drain Pan

1. The condensate pan shall be constructed of high impact plastic to prevent corrosion and sweating. The bottom of the drain pan shall be sloped on two planes to provide complete drainage of water from the pan. The unit shall be supplied with a standard solid-state electronic condensate overflow protection. Water level detection shall comply with U.L. 508. Drain pan shall be insulated to prevent condensation.
2. Electrical
 - a. The factory or field tested and installed control box shall contain all necessary devices to allow heating and cooling operation of the equipment to occur from a remote wall thermostat or zone sensor. Thermostats and zone sensors shall be furnished under Division 23 Section, Instrumentation and Controls of HVAC and Plumbing System. The devices shall be as follows:
 - i. 24 VAC Energy Limiting Class II, 50VA breaker type transformer (minimum)

- ii. 24 VAC contactor for compressor control
- iii. 18 Pole terminal strip located inside the control box behind the service access panel. This terminal strip shall be used for low voltage (thermostat/zone sensor) connections.
- iv. An electrically operated safety lockout relay shall prevent cycling of the compressor during adverse conditions of operation. This device shall be reset either at the remote thermostat/zone sensor, or by cycling power to the unit.
- v. A high pressure switch shall protect the compressor against operation at refrigerant system pressure in excess of 395 psig.
- vi. A low pressure switch shall prevent compressor operation under low charge or catastrophic loss of charge situations.
- vii. Factory installed wire harness.
- viii. Factory installed and wired disconnect switch.

O. Controls

1. Terminal Unit Controller: This system shall utilize factory furnished and mounted DDC controls for operation of a complete building system on a Comm 4 link. The TUC control package shall include a 75 VAC transformer. The controller shall provide anti-short cycle compressor protection, random start, heating/cooling status, occupied/unoccupied mode, as well as fan and filter status options. Optional wiring from the factory for condensate overflow shall be provided. Five LEDs (light emitting diodes) shall also be included for diagnostics of the equipment.
2. BAS Communication Interface: There shall be a BAS Communication Interface that ties into the Unit Control Processor. This system shall provide the following diagnostic information: Communication Network Status at each unit, Mode of Operation, System Cooling and Heating Setpoints, Local Cooling and Heating Setpoints, Compressor Operational Status, Reversing Valve Status, Zone Temperature, Discharge Air Temperature, Leaving Water Temperature, Fan Mode, Fan Status, and Compressor Fault Status.
3. Controls: Factory or Field wired, control shall perform the following:
 - a. Random start of all water source heat pumps.
 - b. Anti-short cycle protection shall prevent rapid cycling of the compressor during changeover from heat to cooling or vice-a-versus.
 - c. A two wire twisted pair shall be able to perform the following functions when connected to the control system: load shedding. Emergency shutdown. Time of day scheduling. Alarm shutdown as a result of: Loss of water flow. High water temperature. Low water temperature.
 - d. Delays shall prevent the reversing valve from changing status against large differentials in pressures within the hermetically sealed system.
 - e. A single common alarm output shall be provided to: Initiate an alarm at the EMS.
 - f. The control system shall monitor the current to the compressor contactor via a high pressure switch. If this switch activates and causes a loss of current to the contactor during a compressor "on mode", then the control system shall shutdown the water source heat pump and cause the common

- alarm output to be energized.
 - g. The controls shall monitor the low refrigerant pressure and if it activates during the compressor "on mode", then the controls shall shutdown the water source heat pump and cause the common alarm output to be energized.
 - h. A freeze protection thermostat shall sense leaving water temperature. If the water temperature falls below the set point, the controls shall shutdown the water source heat pump and cause the common alarm output to be energized.
 - i. The control system shall visually display the following alarm conditions via the BAS. High pressure, Low refrigerant temperature, Condensate overflow.
 - j. The control system shall require a manual reset to restore normal operation after any of the following alarm conditions: high pressure, low refrigerant temperature, or condensate overflow.
 - k. The control system shall visually display the status of the water source heat pump at all times. Definition of all possible status shall be indicated at the BAS.
 - l. The control system shall provide a field service input for diagnostic purposes.
 - m. Condensate overflow switch shall be provided to lock out the compressor operation when a high level of water is detected.
 - n. All water lines, refrigerant lines, hot gas lines and condensate lines shall be fully insulated with 1-inch closed cell insulation.
 - o. The DDC terminal unit controller for each heat pump shall be furnished by the Automatic Temperature Control Contractor for factory installation by the water to air ground source heat pump rooftop unit manufacturer or field installation by the Automatic Temperature Control Contractor.
- 4. The DDC terminal unit controller shall be shipped by the Automatic Temperature Control Contractor to the water to air ground source heat pump rooftop unit manufacturer for installation at the factory. At Contractor's option, the DDC terminal unit controller may be installed in the field.
 - 5. The cost of factory or field mounting, wiring, and any factory testing and programming of the terminal unit controller shall be included by the water to air ground source heat pump rooftop unit manufacturer.
 - 6. The Automatic Temperature Control Contractor shall coordinate with manufacturer to ensure the delivery of factory or field installed controls and proper installation according to the project schedule.
- P. Economizer Control:
- 1. Units shall be factory furnished complete for full enthalpy economizer operation with power relief.
 - 2. Furnish each unit with a factory installed differential electronic enthalpy automatic economizer to accomplish the following:
 - a. Furnish unit with outdoor and return air dampers that are interlocked and

- positioned by a fully-modulating, spring-return damper actuator. The maximum leakage rate for the outdoor air intake damper shall not exceed 2 percent when dampers are fully closed and operating against a pressure differential of .50 inches water gauge.
- b. During economizer operation, a mixed-air temperature controller shall modulate the outdoor and return air damper assembly to prevent the mixed air temperature from dropping below 55 degrees F. Changeover from compressor to economizer operation shall be provided by an integral electronic enthalpy control that feeds input into the logic module. An additional electronic enthalpy sensors shall supply input to the logic module which modulates both sets of dampers for maximum economizer savings. Simultaneous economizer/compressor operation shall be possible for maximum economy.
 - c. The outdoor air intake/relief opening shall be covered with a rain hood that matches the exterior of the unit. The economizer intake opening shall also be covered with a rain hood that matches the exterior of the unit. Water eliminator/filters shall be provided on all intakes.
 - d. Provide and install a power relief air opening covered with a bird screen and hood that is painted to match the exterior of the unit. This opening shall be equipped with a motor operated relief air damper and power relief air fan. Power relief air fan shall operate when economizer damper reaches 30% open.
3. Housing: Piping and electrical shall enter unit concealed within insulated roof curb. All piping within the unit enclosure shall be insulated with insulation type and thickness as specified in Division 23 Section, HVAC Insulation.
- Q. Motors: The motors shall be premium efficiency type with thermal overload protection. Where required, standard static or high static shall be selected and wired from the factory to match performance criteria.
- R. Fans: The fans shall be placed in a draw-through configuration. They shall be constructed of corrosion resistant galvanized material. Fans shall be belt driven, forward covered, centrifugal type with adjustable motor sheaves.
- S. Accessories:
- 1. The following additional accessories/options shall be either factory installed or provided for field installation.
 - a. A 14 inch knockdown roof curb, provided by the same manufacturer, which shall provide a water-tight seal between the roof and the curb. Curbs shall be approved by the National Roofing Contractor Association.
 - b. A 5 minute timer to prevent the compressor from short-cycling.
 - c. A lockout circuit to prevent the compressor from cycling on one of the safety controls.
- T. Source Quality Control.
- 1. Verification of Performance: Rate capacity according to ARI 210/240, "Unitary Air-conditioning and Air Source Heat Pump Equipment."

2. Verification of Performance: Rate capacity according to ARI 360, "Commercial and Industrial Unitary Air-Conditioning Equipment."
 3. Sound Power Level Ratings: Comply with ARI 270, "Standard for Sound Rating of Outdoor Unitary Equipment."
 4. Sound Power Level Ratings: Comply with AMCA Standard 300 to generate supply air borne and return air borne sound power ratings.
- U. Warranty; The unit shall be warranted by the manufacturer against defects in material and factory workmanship for two (2) years. The refrigerant circuit including motor-compressor, expansion device, all heat exchangers in contact with refrigerants, and reversing valve (less solenoid coil) shall be warranted for four (4) additional years.

2.21. BOILER BUFFER TANKS

- A. Provide and install a heating hot water storage buffer tank for use with boilers of the size, dimensions, and capacity as indicated on the contract drawings.
- B. The storage tank shall be a vertical Lochinvar Lock-Temp "Energy Saver", A.O. Smith, Reco or approved equal tank having a storage capacity as indicated on the contract drawings. The tank shall be constructed with an inner chamber designed to receive all circulation to and from the boilers to eliminate turbulence in the tank. The baffled tank shall supply 80 percent of tank capacity without a drop in outlet temperature, regardless of rate of draw.
- C. The storage tank shall be constructed in accordance with ASME Boiler and Pressure Vessel Code requirements, ASME - stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors. The storage tank shall have a working pressure of (125 psig). The storage tank shall be glass lined and fired to 1600 degrees F to insure a molecular fusing of glass and steel furnished with magnesium anodes and carry a five (5) year limited warranty.
- D. The storage tank shall be furnished with a factory installed jacket of 16GA steel, galvanized inside and out and finished with three coats of acrylic enamel. The jacket and tank base shall be a water tight construction with a built-in drain pain, complete with a 3/4-inch drain connection to assist in protecting against damage in the event of a tank or component leakage. The storage tank shall be completely encased in high density fiberglass insulation of sufficient thickness to meet the energy efficient requirements of the latest edition of the ASHRAE 90.1. Standard including addendums. The entire tank assembly shall be mounted on channel steel skids to facilitate handling and installation.
- E. Tank shall be furnished with a manhole.
- F. Tank shall be factory furnished with all inlet, outlet, thermometer, relief-valve, temperature sensor and thermostat tapings.
- G. Mount tank on a 4-inch high housekeeping pad.
- H. Provide factory furnished and installed A.S.M.E. pressure/ temperature relief valve. Pipe

relief valve to nearest floor drain with union on discharge piping.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Verify all dimensions by field measurements. Verify that all equipment may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- B. Verify structure, mounting supports and membrane installations are completed to the proper point to allow installation of roof mounted equipment, where applicable.
- C. Examine rough-in requirements for all piping systems to verify actual locations of piping connections prior to installation.
- D. Verify that electrical work installation is in accordance with manufacture's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until electrical work is acceptable to equipment installer. Coordinate sizes of all thermal overloads with Division 26.
- E. Do not proceed until unsatisfactory conditions have been corrected.
- F. Provide wiring diagrams of all equipment as specified in Division 23 Section, Common Work Results for HVAC.

3.2. GENERAL INSTALLATION REQUIREMENTS

- A. Install all equipment in accordance with manufacturer's installation instructions, in accordance with state and local code requirements, and in accordance with the contract drawings. Install all equipment plumb and level, to tolerances as required by the manufacturer of each item of equipment. Maintain manufacturer recommended clearances around and over all equipment. Boiler minimum clearances shall be provided per the State Requirements.
- B. Coordinate vibration isolation requirements with all equipment in accordance with Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment.
- C. Coordinate all electrical requirements with Division 26.
- D. Coordinate all indoor and outdoor equipment pad locations and sizes with approved shop drawing submittals. Provide operating weights of equipment to Structural Engineer for review. Coordinate equipment pad locations and sizes with the Concrete Contractor or General Contractor. Furnish anchor bolts which are to be inserted in concrete pads to concrete installer.
- E. Verify piping arrangements of all equipment with the contract drawings. Piping details shall be strictly adhered to concerning valves, fittings, components, etc. At coils, where a rebuildable and repairable autoflow valve is installed in the line without the need for draining or shutting of the water, the same may be utilized as the isolation valve and

additional shut-off valve is not required.

- F. Connect all equipment, devices and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.
- G. Testing: After installing HVAC equipment, devices and components and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
- H. Remove and replace malfunctioning units with new units and retest.
- I. All mechanical penetrations or terminations in exterior walls shall be flashed and caulked watertight.
- J. Arrange for equipment such as boilers, air handling units, energy recovery units, heat pumps to be shipped to project in modules where space constraints require the same. Field erect components as required.

3.3. FIELD QUALITY CONTROL

- A. Where indicated provide the services of a factory authorized service representative to examine the field assembly of components, installation, piping, electrical connections, controls, and clearances. Submit factory start-up check list to Engineer for information purposes. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.
- B. Where factory start-up of equipment is not specified, provide field start-up by qualified technician to examine the field assembly of components, installation, piping, electrical connections, controls and clearances. Record equipment manufacturers standard start-up information and submit to Engineer for review. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.
- C. Charge all refrigerant systems with refrigerant and oil and test for leaks. Repair leaks and replace lost refrigerant and oil.
- D. Fill all hydronic systems with water and/or antifreeze (when required after flushing and test for leaks. Repair leaks and replace lost water and/or antifreeze. Coordinate with water treatment contractor.
- E. Submit to Engineer a written table of all relief valve and make-up water valve settings for each system. Provide an additional copy in the Operations and Maintenance Manuals.
- F. Verify proper motor sizes, voltages, thermal overloads, nameplate data, etc. All equipment voltages and current shall be recorded to insure that motors are operating below their service factors. Test and Balance Engineer shall record electrical data before continuous or permanent operation.

3.4. DEMONSTRATION

- A. Provide the services of a factory authorized service representative to provide start-up and to demonstrate and train the Owner's maintenance personnel.
- B. Place equipment into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.
- C. Training:
 - 1. Train the Owner's maintenance personnel on start-up and shut-down procedures, trouble shooting procedures, lubrication, servicing procedures and preventative maintenance schedules/procedures. Review with the Owner's personnel, the contents of the operation and maintenance data specified in Division 23 Section, Common Work Results for HVAC.
 - 2. Submit operation and maintenance data as soon as possible prior to project close-out. Operations and maintenance data shall be submitted to the Owner for review and comment prior to submission to the Engineer.
 - 3. Schedule training with the Owner through the Architect and/or Engineer with at least seven (7) days prior notice.
- D. Contractor shall demonstrate removal and replacement of filters at all pieces of equipment with filters in the presence of the Owners representative.

3.5. CLEANING

- A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.
- B. Clean fan and equipment interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering air face.

3.6. DUCTLESS UNITS EQUIPMENT INSTALLATION REQUIREMENTS

- A. Mount indoor and outdoor units as detailed on contract drawings.
- B. Supply initial charge of refrigerant and oil as required.
- C. Install all interlock and control wiring between indoor units, outdoor units thermostats, and condensate pumps.
- D. Install indoor ceiling cassette on vibration isolators.
- E. Install outdoor units on concrete pads or on roof curbs as indicated on drawings.
- F. Comb out fins on condensing unit where deformed or bent. Replace or repair broken fins.
- G. Install condensate lift pumps, float switches, alarm, unit shut down wiring and detection block units per manufacturer's recommendations.

- H. For wall mounted units, locate condensate pumps above ceiling. Install all piping, tubing between indoor unit, adapter, detection block, and condensate pump.
- I. For wall mounted units field wire power wiring, alarm circuits, control cable, safety circuit connection, alarm, and condensate pump. Condensate pump shall be powered from indoor unit power wiring. Coordinate condensate pump electrical characteristics with indoor unit electrical characteristics.
- J. Install wind baffles when required for low ambient operation. Locate wind baffles facing the predominant wind direction in winter.

3.7. ELECTRIC HEATING EQUIPMENT INSTALLATION REQUIREMENTS

- A. Examine heating units for compliance with requirements for installation tolerances and other conditions affecting performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Connect heating units and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.
- C. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris; repair damaged finishes, including chips, scratches, and abrasions.

3.8. FAN INSTALLATION REQUIREMENTS.

- A. Install fans with resilient mounting and flexible electrical leads.
- B. Install flexible connections and vibration isolators as specified in Division 23 Section, Common Work Results for HVAC and Division 23 Section Vibration Controls for HVAC, Plumbing and Fire Protection Equipment. Ensure metal band of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- C. Provide safety screens/guards on all fans and permanently mount after final testing and balancing.
- D. Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated, and fans have been test run under operation.
- E. Provide sheave required for final air balance.
- F. Install fans according to manufacturer's written instructions.
- G. Adjust damper linkages for proper damper operation.
- H. Adjust belt tension.
- I. Lubricate bearings.

- J. Replace fan and motor pulleys and belts as required to achieve design conditions.
- K. Mount, install, and wire speed controllers for direct drive fans. Speed controllers for direct drive fans shall be mounted adjacent to fan and wired in accordance with the NEC.

3.9. BOILER INSTALLATION REQUIREMENTS

- A. Install boilers in accordance with NFPA-54, NPFA-31 Delaware Boiler and Pressure Vessel Safety Act including ASME CSD-1, Amendments and Addenda, latest edition, State of Delaware Requirements. Coordinate inspection of boiler by local Boiler Inspector or authority having jurisdiction. Correct any and all violations noted by Boiler Inspector at no additional cost to the Owner.
- B. Install boilers on concrete housekeeping pads.
- C. Provide connections of fuel source piping in accordance with codes listed above. All gas regulators and gas pressure relief valves shall be piped to the building exterior and terminated with a gooseneck and vermin screen as required in CSD-1. Gas regulator and gas relief valve pipe material shall be in accordance with A.S.M.E. Code.
- D. Provide piping connections and accessories as specified and detailed on drawings. For hot water piping all piping up to the first OS&Y gate valve on each side of the boiler shall be welded, flanged or screwed. Grooved joint piping is not acceptable until after the OS&Y gate valve on each side of the boiler.
- E. Pipe all relief valves to nearest floor drain. Support relief valve piping in accordance with A.S.M.E. requirements. Relief valve pipe material shall be in accordance with A.S.M.E. Code. Install no more than one (1) elbow on safety relief valve discharge pipe located close to the valve outlet downstream of the union.
- F. Provide for connection to electrical services.
- G. Provide for connection to gas pilot piping including strainer, shut-off valve, unions, and regulators.
- H. Install boilers level and plumb, according to manufacturer's written instructions and referenced standards.
- I. Assemble boiler sections in sequence and seal between each section. Assemble boiler trim according to manufacturer's written installation instructions.
- J. Install electrical devices furnished with boiler, but not specified to be factory mounted. Mount, install, and wire low water cutoffs and gas train valves. Low water cut offs and gas train valves shall be installed per manufacturers recommendations and wired in accordance with the National Electric Code.
- K. Connect breeching to boiler outlet, full size of outlet.
- L. Electrical: Comply with applicable requirements in Division 26.
- M. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- N. Manufacturer's Field Service: Engage a factory authorized service representative to supervise the field assembly of components and installation of boilers, including piping and electrical connections. Report results in writing.
 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 2. Submit flue gas and combustion analysis reports to Engineer.
 3. Record design and actual draft available at appliance vent connection.
- O. Hydrostatically test assembled boiler and piping, according to applicable sections of the ASME Boiler and Pressure Vessel Code.
- P. Flush and clean boilers on completion of installation, according to manufacturer's written instructions.
- Q. After completing boiler installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes including chips, scratches, and abrasions with manufacturer's touch up paint.
- R. Furnish and install condensate neutralizers with lime chips and pipe discharge as indicated. Connect condensate neutralizers to boilers and flue pipes.
- S. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- T. Examine mechanical spaces for suitable conditions where boilers will be installed.
- U. Proceed with installation only after unsatisfactory conditions have been corrected.
- V. Equipment Mounting:
 1. Install boilers on cast-in-place concrete equipment base(s).
 2. Mount valves and devices at heights required by the Boiler Inspector.
- W. Install gas-fired boilers according to NFPA 54.
- X. Assemble and install boiler trim.
- Y. Install electrical devices furnished with boiler but not specified to be factory mounted.
- Z. Install control wiring to field-mounted electrical devices.

- AA. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. All boiler relief valve and drain piping shall be Type L copper piping.
- BB. Install piping adjacent to boiler to allow service and maintenance.
- CC. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve. Drain valves shall be brass, ball type and not less than 1-inch. Pipe ends shall be cut at 45 degree angle to prevent a cap or plug from being installed.
- DD. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. All relief valve discharge piping shall be fully supported to prevent undue stress or strain.
- EE. Connect gas piping to boiler gas-train inlet with union and shut-off valve. Piping shall be at least full size of gas train connection. Provide a reducer if required. Furnish and install gas pressure regulators as required.
- FF. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
- GG. Connect flow switch to hot water piping and interlock with boiler and ATC system.
- HH. Install piping from safety relief valves to nearest floor drain.
- II. Boiler Venting:
 - 1. Install flue venting kit, flue stack thermometer, roof curbs, cleanouts, and combustion-air intake.
 - 2. Connect full size to boiler connections.
 - 3. For condensing boilers connect flue and combustion air ducts to full size boiler.
- JJ. Ground equipment according to Division 26, Section "Grounding and Bonding."
- KK. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- LL. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning

controls and equipment.

- a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
- b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

MM. Remove and replace malfunctioning units and retest as specified above.

NN. Prepare test and inspection reports.

OO. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

PP. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.
 - a. Test for full capacity.
 - b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

QQ. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers.

3.10. HVAC PUMP INSTALLATION REQUIREMENTS

- A. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.
- B. Lubricate pumps before start-up.
- C. Install pumps according to manufacturer's written instructions.

1. Install pumps according to HI 1.1 1.5, Centrifugal Pumps for Nomenclature, Definitions, Application and Operation.
- D. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.
- E. Suspend in line pumps using continuous thread hanger rod and vibration isolation hangers. Install kindorf pump supports for vertical in-line pumps and maintain space above motors for future removal.
- F. Set base mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.
 1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1 1/2 inches between pump base and foundation for grouting.
 2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

3.11. HYDRONIC EQUIPMENT AND SPECIALITIES INSTALLATION REQUIREMENTS

- A. Where large air quantities can accumulate, provide enlarged air collection standpipes.
- B. Provide manual air vents at system high points and as indicated.
- C. For automatic air vents provide vent tubing to nearest drain.
- D. Provide air separator on suction side of system circulation pump and connect to expansion tank.
- E. Provide valved drain and hose connection on strainer blow down connection.
- F. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.
- G. Support pump fittings with floor mounted pipe and flange supports.
- H. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment and in accordance with ASME requirements.
- I. Pipe all relief valve outlets to nearest floor drain.
- J. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.
- K. Perform test determining strength of antifreeze and water solution and submit written test results.
- L. Install equipment exposed to finished area after walls and ceiling are finished and painted.

Avoid damage.

- M. Protection: Provide finished cabinet units with protective covers during balance of construction.
- N. Unit heaters: hang from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.
- O. Cabinet Unit Heaters: Install as indicated. Coordinate to assure correct recess size for recessed units.
- P. Testing: After installing and connecting units, demonstrate product capability and compliance with requirements.
- Q. Remove and replace malfunctioning units with new units and retest.

3.12. ROOFTOP UNITS INSTALLATION REQUIREMENTS

- A. Verify that roof is ready to receive work and opening dimensions are as required.
- B. Mount unit on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.
- C. Coordinate installation of roof curbs, equipment supports and roof penetrations with roof construction. Service platform shall bolt to curb per manufacturer's requirements with stainless steel hardware.
- D. Examine roof for compliance with requirements for conditions affecting installation and performance of rooftop units. Do not proceed with installation until unsatisfactory conditions have been corrected.
- E. Install units according to manufacturer's written instructions.
- F. Install units level and plumb, maintaining manufacturer's recommended clearances.
- G. Curb Support: Install roof curb on roof structure, level, according to NRCA's written installation instructions. Install and secure rooftop units on curbs and coordinate roof penetrations and flashing with roof construction.
- H. Unit Support: Install unit on structural curbs and level. Coordinate wall penetrations and flashing with wall construction.
- I. Provide factory start-up and training. Submit start-up reports to Engineer.
- J. Examine areas to receive units for compliance with requirements for installation tolerances and other conditions affecting performance of energy recovery units. Do not proceed with installation until unsatisfactory conditions have been corrected.
- K. Install and interlock air flow monitoring stations.
- L. Install new filters at completion of equipment installation and before testing, adjusting, and

balancing.

- M. Ducts and fan installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.
- N. Ground Equipment
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- O. After completing system installation, including outlet fittings and devices, inspect and clean exposed finishes. Remove dirt and construction debris and repair damaged finishes.
- P. Startup Services: Engage a factory-authorized service representative to commission units as specified below.
 - 1. Energize and verify correct rotation of heat wheels and fans.
 - 2. Adjust seals and purge.
 - 3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
 - 4. Test refrigerant circuit and controls.
 - 5. Record refrigerant pressures.
 - 6. Verify sequence of operation.
 - 7. Test variable air flow operation.
 - 8. Test economizer operation and relief air fan.
 - 9. Test dehumidification system and hot gas re-heat coil operation.
- Q. Training
 - 1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.
 - 2. Review data in the operation and maintenance manuals. Refer to Division 01 Section, Demonstration and Training.
 - 3. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.13. WATER TREATMENT INSTALLATION REQUIREMENTS

- A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.

- B. Place terminal control valves in open position during cleaning. Open bypass valves on coils and close isolation valves on coils during initial flushing.
- C. Verify that electric power is available and of the correct characteristics.
- D. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect.
- E. Flush open systems and closed systems with clean water for one hour minimum. Drain completely and refill.
- F. Remove, clean, and replace strainer screens.
- G. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.
- H. Test and submit antifreeze concentration where the same is utilized.

3.14. ENERGY RECOVERY VENTILATOR INSTALLATION REQUIREMENTS

- A. Examine areas to receive energy recovery units for compliance with requirements for installation tolerances and other conditions affecting performance of energy recovery units. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Install energy recovery units as indicated, according to manufacturer's written instructions.
- C. Install CO₂ sensor/control/interlock wiring to variable frequency drives and to ATC system. Install global CO₂ sensor to monitor ambient outside air CO₂ level.
- D. Install and interlock space CO₂ sensors.
- E. Install heat wheels so supply and exhaust flow in opposite directions and rotation is from exhaust side to purge section to supply side.
 - 1. Provide access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
 - 2. Provide removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
- F. Install and interlock air flow monitoring stations.
- G. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
- H. Ducts and fan installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.
- I. Ground Equipment
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated,

use those specified in UL 486A and UL 486B.

- J. After completing system installation, including outlet fittings and devices, inspect and clean exposed finishes. Remove dirt and construction debris and repair damaged finishes.
- K. Startup Services: Engage a factory-authorized service representative to commission units as specified below.
 - 1. Energize and verify correct rotation of heat wheels and fans.
 - 2. Adjust seals and purge.
 - 3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
 - 4. Test refrigerant circuit and controls.
 - 5. Record refrigerant pressures.
 - 6. Verify sequence of operation.
 - 7. Record fluid temperatures and flow rates.
 - 8. Verify and record minimum and maximum air flow rates for the supply and exhaust air fan.
 - 9. Verify and record the minimum and maximum supply/exhaust fan speeds/ hertz and incorporate into the fan tracking sequence of operation.
 - 10. Test A/C condensate overflow safety switch.
 - 11. Test hot gas re-heat coil operation.
 - 12. Verify and record the minimum and maximum supply/exhaust fan speeds/hertz and incorporate into the fan tracking sequence of operation.
- L. Training
 - 1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.
 - 2. Review data in the operation and maintenance manuals. Refer to Division 01 Section, Demonstration and Training.
 - 3. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.15. WATER SOURCE HEAT PUMP EQUIPMENT INSTALLATION REQUIREMENTS

- A. Examine areas and conditions for compliance with requirements for installation tolerances, other specific conditions, and other conditions affecting performance of water-source heat pumps. Do not proceed with installation until unsatisfactory conditions have been

corrected.

- B. Examine piping and electric rough installations for water-source heat pumps to verify actual locations of piping connections before installation.
- C. Install water-source heat pumps according to manufacturer's written instructions.
- D. Install units level and plumb, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances. Install water-to-water heat pumps on vibration isolation pads and concrete housekeeping pads.
- E. Piping Connections: Drawings indicate the general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Connect supply and return piping to heat pump with unions and shutoff valves.
 - 2. Connect refrigerant piping to fan coil units and heat pumps. Size and install refrigerant piping per heat pump unit manufacturer.
 - 3. Connect heat-pump drain pan to nearest indirect waste connection, air conditioning condensate pump or as indicated.
- F. Duct Connections: Connect supply and return ducts to heat pumps with flexible duct connections. Provide transitions to match unit duct-connection size. Completely seal and insulate where ductwork connects to unit and filter rack.
- G. Install electrical devices furnished by manufacturer but not specified to be factory mounted.
- H. Connect low voltage safety switch wiring to heat pumps where air conditioning condensate pumps are indicated.
- I. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- J. Replace filters used during construction. Seal all return air ducts to filter racks. Seal air tight all filter racks.
- K. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of water-source heat pumps, including piping and electrical connections. Report results in writing.
 - 1. Test and adjust controls and safeties.
 - 2. Replace damaged and malfunctioning controls and equipment.
 - 3. Test and record refrigerant pressures, air flow rates, water flow rates, electrical characteristics. Start-up company and Test and Balance Engineer must both be present during start-up to simultaneously record the above data.

4. Test flow switches.
 5. Test dehumidification mode and hot gas re-heat valve operation.
 6. Test economizer operation and power relief air fan.
- L. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
 2. Review data in the maintenance manuals specified in Division 01.
 3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.
- M. Maintain minimum of 24 inches clear space at heat pump filter access. Provide manufacturer required clearances for service at ATC control panel, fan section, compressor section and electrical section. Maintain sufficient clear space below units to allow lowering and raising of units in the future.
- N. All water source heat pumps shall be provided with auto-restart in the event of a power outage. Units shall automatically be enabled to re-start when power is restored.

END OF SECTION

DIVISION 23 SECTION 230701
HVAC INSULATION
TABLE OF CONTENTS

PART 1. GENERAL	1
1.1. REFERENCE	1
1.2. DESCRIPTION	1
1.3. SCOPE.....	1
1.4. STANDARDS	1
1.5. SYSTEM PERFORMANCE	2
1.6. QUALITY ASSURANCE.....	2
1.7. DELIVERY AND STORAGE OF MATERIALS	2
1.8. ALTERNATES	3
PART 2. PRODUCTS.....	3
2.1. GENERAL.....	3
2.2. PIPE INSULATION MATERIALS	3
2.3. PIPING INSULATION THICKNESSES SCHEDULE	6
2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES.....	6
2.5. DUCTWORK INSULATION MATERIALS AND THICKNESSES.....	8
2.6. ACCESSORY MATERIALS	9
2.7. HANGER BLOCKS	10
PART 3. EXECUTION.....	10
3.1. WORKMANSHIP	10
3.2. SITE INSPECTION.....	10
3.3. PREPARATION.....	10
3.4. INSTALLATION	11
3.5. FIELD QUALITY ASSURANCE.....	14
3.6. PROTECTION	15
3.7. SAFETY PRECAUTIONS.....	15
3.8. INSULATION COVERING.....	15

SECTION 23 07 01

HVAC INSULATION

PART 1. GENERAL

1.1. REFERENCE

- A. The Conditions of the Contract and other General Requirements apply to the work specified in this Section. All work under this Section shall be subject to the requirements of Division 23 Section, Common Work Results for HVAC.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section

1.2. DESCRIPTION

- A. All piping, ductwork, and equipment installed under this Contract shall be covered as specified.

1.3. SCOPE

- A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to all piping, equipment, and duct systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract.

1.4. STANDARDS

- A. Thermal insulation materials shall meet the property requirements of one or more of the following specifications as applicable to the specific product or use:
 - 1. American Society for Testing of Materials Specifications:
 - a. ASTM C 547, "Standard Specification for Mineral Fiber Preformed Pipe Insulation".
 - b. ASTM C 533, "Standard Specification for Calcium Silicate Pipe & Block Insulation".
 - c. ASTM C 55, "Standard Specification for Mineral Fiber Blanket and Felt Insulation".
 - d. ASTM E 96, "Standard Test Methods for Water Vapor Transmission of Material".
 - e. ASTM C 585, "Recommended Practice for Inner and Outer Diameters of Rigid Pipe Insulation for Nominal Sizes of Pipe and Tubing (NPS System)".
 - f. ASTM C 612, "Standard Specification for Mineral Fiber Block and Board Thermal Insulation".
 - g. ASTM C 1136, "Standard Specification for Barrier Material, Vapor, "Type 1 or 2 (Jacket only)".

2. ASHRAE 90.1 "Energy efficient design of new buildings except low-rise residential buildings", latest edition.
 3. International Energy Conservation Code, latest edition.
- B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers, and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications.

1.5. SYSTEM PERFORMANCE

- A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) (formerly known as TIMA), to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1, (latest edition) and "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), latest edition. However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. As minimum, all insulation thicknesses shall be as hereinafter specified.
- B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirements of any one of the following specifications:
1. American Society for Testing of Materials ASTM E 84
 2. Underwriters' Laboratories, Inc. UL 723
 3. National Fire Protection Association NFPA 255
 4. ASTM E 96, "Standard Test Methods for Water Vapor Transmission of Materials".
- C. Calcium silicate products shall include a visual identification system to permit positive field determination of their asbestos-free characteristics.

1.6. QUALITY ASSURANCE

- A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.
- B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

1.7. DELIVERY AND STORAGE OF MATERIALS

- A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

- B. The Contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use all means necessary to protect work and materials installed by other trades.
- C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the Contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the Contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer in writing for technical assistance.
- D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Protect all insulation from water, construction traffic, dirt, chemical and mechanical damage.

1.8. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. GENERAL

- A. All materials to be insulated shall be thoroughly cleaned, after completion of successful tests, and shall be covered as specified below. Fiberglass insulation shall be Owens-Corning, Manville, Armstrong, or P.P.G, or as approved equal.

2.2. PIPE INSULATION MATERIALS

- A. Unless otherwise noted, insulation shall be one piece or half sectional molded fibrous glass with "K" rating of .23 at 75 degrees Fahrenheit mean temperature, for service temperatures between -60 degrees Fahrenheit and +450 degrees Fahrenheit with all service poly-encapsulated jacket. Pipe insulation shall be fiberglass ASJMax SSL II with double closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.
- B. Exterior refrigerant pipe insulation shall be Armacell, or approved equal, foam insulation with exterior field applied aluminum jacketing. Interior refrigerant piping shall be Armacell or approved equal foam insulation. Where interior refrigerant piping is exposed also install field applied PVC jacketing.
- C. Unless otherwise noted, pipe insulation jacket shall be factory-applied vinyl coated, embossed and reinforced vapor barrier laminate, with a perm rating of not more than 0.02 perms. All hot and cold, concealed and exposed butt strips shall be of the same material as the jacket. Jacket and butt strips shall be sealed with field-applied Foster 85-20/85-60 or Childers CP-82 (5 gal cans only) adhesive. Jacket and butt strips shall be off-white color and shall be equivalent to Owens-Corning Fiberglass 25-ASJ.

- D. For fittings on all piping, valves and flanges, apply fiberglass molded or segmented insulation equal in thickness to the adjoining insulation and securely fasten in place using wire. Cold piping: Apply a tack coat of vapor barrier coating and reinforcing mesh. After ½ hour, apply second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping, Hot piping Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of breather mastic over the reinforcing cloth, working it to a smooth finish.
1. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeanie shall be 0.03 perms or less at 45 mils dry as test by ASTM E96.
 2. Breather mastic: Foster 46-50; Childers CP-10/11 or Vimasco WC-5
 3. Reinforcing Mesh: Foster Mast a Fab; Childers Chil Glas #10 or Vimasco Elastafab
- E. All pipe insulation, jackets, or facings, and adhesives used to adhere jacket or facing to the insulation, including fittings and butt strips, shall have non-combustible fire and smoke hazard system rating and label as tested by ASTM E-84, NFPA 225, and UL 73, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50. Accessories such as adhesives, mastic cements, tapes and cloth for fittings shall have the same ratings as listed above. All products or their shipping cartons shall bear the Underwriter's label indicating that flame and smoke ratings do not exceed the above criteria.
- F. For piping having a vapor barrier insulation and for all insulated piping requiring supports, hangers and supports shall be installed outside the insulation. Wherever hangers and supports are installed outside the insulation, pipe insulation protecting shields shall be provided. Where insulation is a load bearing material, of sufficient strength to support the weight of the piping, pipe shields one-third the circumference of the insulation and of a length not less than three times the diameter of the insulation (maximum length 24-inches) shall be provided. Insulation of 7-1/4 pound or greater density will be considered as load bearing for pipe sizes up to and including 2-inches. Where insulation is not of sufficient strength to support the weight of the piping, a half section of high density fiberglass or foam inserts, shall be provided. Vapor barrier and finish shall be applied as required to match adjoining insulation. In addition, shields shall be furnished as specified above.
- G. For piping located outside of the building, a corrugated aluminum weatherproof jacketing system shall be provided. This system shall be Micro-Lot ML as manufactured by Manville, Polyweld by Pabco Metals Corp., Childers, or as approved equal, and installed per the manufacturer's recommendations. Where outdoor piping is receiving electric heat tape, the insulation shall be oversized so that the heat tape is not compressed tightly to the pipe. Pipe jacketing shall be corrugated (3/16-inch) deep aluminum, .016-inch thickness of H-14 temper with aluminum strapping of .75-inch width and .020 inch thickness with moisture barrier. Aluminum jacketing elbows shall be smooth, .016-inch thickness and 1100 alloy. All jacketing shall have an integrally bonded moisture barrier over the entire surface in contact with the insulation. Longitudinal joints shall be applied so they will shed water and shall be sealed completely with metal jacketing sealant. Sealant shall be Foster 95-44 or Childers CP-76. Circumferential joints shall be closed using preformed butt strips following manufacturer's recommendations for securement. Jacket seams shall be located

on the bottom side of the horizontal piping.

- H. All disturbed piping insulation in existing areas shall be re-insulated with insulation type, density, and thickness as specified for new piping. Insulation damaged due to new work and demolition only shall be replaced unless otherwise noted.
- I. On cold systems such as refrigerant piping, cooling coil drain piping, glycol piping, and geothermal (condenser) heat pump piping, etc. vapor barrier performance is extremely important. All penetrations and seams of the ASJ and exposed ends of insulation must be sealed with vapor barrier coating. The ASJ must be protected with either a coating or a suitable vapor retarding outer jacket. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeance shall be 0.03 perms or less at 45 mils dry as test by ASTM E96.
- J. Fittings and valves shall be insulated with pre-formed fiberglass fittings, fabricated sections of fiberglass pipe insulation, Fiberglass pipe and tank insulation, Fiberglass blanket insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. Finish shall be with pre-formed PVC fitting covers or as otherwise specified on contract drawings. Where applicable, Victaulic PVC fitting valve and coupling covers shall be utilized. Victaulic PVC covers shall be installed with matching pipe insulation jacketing material, vinyl tape solvent weld adhesive and appropriate fasteners.
 - 1. Flanges, couplings and valve bonnets shall be covered with an oversized pipe insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends shall be coated with a suitable weather or vapor-resistant mastic as dictated by the system location and service. Finish valve installation with a Tyvac jacket with ends that secure to adjacent piping.
 - 2. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.
 - 3. On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems must be sealed with caulking which allows free movement of the stem but provides a seal against moisture incursion. All gauge and thermometer penetrations and extensions shall be correctly sealed and insulated to prevent surface condensation. Install oversized hangers to prevent penetrations of pipe insulation vapor barrier.
- K. All piping shall be supported in such a manner that neither the insulation or the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing must be such that the circumferential joint may be made outside the hanger. On cold systems, vapor barrier must be continuous, including material covered by the hanger saddle.
 - 1. Piping systems 3-inches (7.5cm) in diameter or less, insulated with Fiberglass insulation, may be supported by placing saddles of the proper length and spacing,

as designated in Owens-Corning Pub. 1-IN-12534, under the insulation. Hangers saddles shall be minimum 16 gauge with a saddle arc of 120 degrees minimum.

2. For hot or cold piping systems larger than 3-inches (7.5 cm) in diameter, operating at temperatures less than +200 degrees F (93 degrees C) and insulated with fiber glass, high density inserts such as foam or wood blocks with sufficient compressive strength shall be used to support the weight of the piping system. At temperatures exceeding +200 degrees F (93 degrees C), Owens-Corning Pink Calcium Silicate, IIG, or approved equal pipe insulation shall be used for high density inserts.
3. Owens-Corning Pink Calcium Silicate pipe insulation may be used to support the entire weight of the piping system provided the hanger saddle is designed so the maximum compressive load does not exceed 100 psi (7kg/cm).
4. Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.
5. Thermal expansion and contraction of the piping and insulation system shall generally be taken care of by utilizing double layers of insulation and staggering both longitudinal and circumferential joints. Where long runs are encountered, expansion joints may be required where single layers of insulation are being used and should be so noted on the contract drawings.
6. On vertical runs, insulation support rings shall be used.

2.3. PIPING INSULATION THICKNESSES SCHEDULE

- A. All piping shall be insulated with pipe insulation of the thicknesses indicated below:

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
All Branch Runouts to Unit Heaters	½-inch thickness
Interior Geothermal and Condenser Water Piping	1 ½ -inch thickness
Heating Hot Water Piping 2-inches & Larger	2 -inch thickness
Heating Hot Water Piping 1-½ -inches & Smaller	1 ½ -inch thickness
All Drain Piping from Cooling Coils/Evaporators	1-inch thickness
Chemical Feed System	inch thickness
All Above Grade Floor Drain Piping Serving AHU Condensate Drains include Drain Sumps and Auxiliary Drain Pipes from Auxiliary Pans	1-inch thickness
All Refrigerant Piping	1-inch thickness

2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES

- A. The following equipment shall be insulated with Fiberglass Rigid Board Insulation or Foam Plastic Insulation:

1. Geothermal (Condenser Water) Pump Bodies.
 2. Air Separators.
 3. Expansion Tanks.
 4. Chemical Feed Tanks.
 5. Freeze Protection Pump Bodies.
 6. All Pump Volute and Strainers.
- B. Insulation for cold surfaces shall be 1-1/2-inch thickness, 6 lb. density, 705 FRK with a "K" rating of .23 at 75 degrees F mean temperature. Insulation for hot surfaces except as otherwise noted shall be 1-1/2-inch thickness, 6 lb. density, 705 with a "K" rating of .23 at 75 degrees F mean temperature. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be 1-inch by 25 gauge galvanized steel spaced on not over 12-inch centers. All joints and voids shall be filled with Owens-Corning #110 cement, well troweled into openings. For 705 FRK insulation, all joints and voids shall be FRK taped and vapor sealed. There shall be applied over the insulation surface 1-inch galvanized wire netting laced together at all edges and wired to the steel bands with 16 gauge soft annealed wire. Over this shall be applied 2-inch thick layer of Owens-Corning #110 cement applied in two layers. Install metal corner beads at all corners and edges in order to provide a permanent installation. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive at the rate of 60-70 square feet per gallon. Embed into wet coating a layer of 8 ounce canvas or fiberglass lattice mesh smoothed out to avoid wrinkles and lap all seams a minimum of 2-inches. Apply a second brush coat of Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive to the entire surface at the rate of 60-70 square feet per gallon. Cleanouts, nameplates, and manholes shall not be insulated, and the insulation on surrounding surfaces shall be neatly beveled off at such openings.
- C. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
 2. Fabricate boxes from aluminum at least 0.040 inch (1.0 mm) thick.
 3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.
- D. Boards shall be scored to allow them to conform to curved or irregular surfaces.
- E. Mechanical fasteners shall be utilized to hold insulation to surface with bands as required to hold the curvature of the material.

- F. Support rings shall be provided to support the top head insulation where required.
- G. Outdoor installations require a weather barrier for protection of the insulation jacketing.
- H. Insulation types materials shall be suitable for temperatures encountered by each item of equipment.

2.5. DUCTWORK INSULATION MATERIALS AND THICKNESSES

- A. Insulate all supply, return, relief, combustion air, plenums, and outside air intake ductwork with fiberglass exterior duct insulation with factory-applied foil facing. All exposed fiberglass duct insulation shall be 2-inch rigid or non-flexible board type 3.0 pcf minimum density, 0.23 max. "K" factor at 75 degrees F mean temperature, with white vinyl A.S.J. max, polymer coating vapor barrier facing. All concealed fiberglass duct insulation shall be 2-inch flexible blanket type, 1.0 pcf minimum density. All concealed insulation shall be 0.27 max. "K" factor at 75 degrees F mean temperature with reinforced foil-scrim Kraft vapor barrier facing. Unless otherwise noted, the minimum installed R-value shall be 6.0 HR x ft² x °F/btu.
- B. Refer to Division 23 Section, HVAC Air Distribution System and contract drawings for location of all sound-lined ductwork. Sound-lined ductwork from the discharge or supply side of all air handling units, energy recovery units, heat pumps, rooftop units, and single zone VAV unit shall require external insulation in addition to internal lining specified hereinafter. All other ducts indicated to be provided with interior lining shall not require additional exterior insulation.
- C. Where exhaust ducts carrying moisture-laden air, shower exhaust, etc. are routed in unconditioned spaces, insulation is required as described above. Insulation shall be continuous through the unconditioned area. The vapor barrier shall be tightly sealed to prevent condensation. Exhaust ducts located within conditioned spaces do not require insulation unless otherwise noted.
- D. Where a vapor barrier is required, all joints, seams, tears, punctures, and other penetrations shall be closed with 3-inch (7.5cm) pressure-sensitive tape matching the facing or with vapor barrier coating reinforced with 3-inch (7.5cm) glass scrim tape.
- E. Exposed dual wall ductwork located in finished areas shall not require additional exterior insulation. Exposed dual wall supply ductwork located in mechanical room, fan rooms, penthouse, mezzanines and boiler rooms shall require additional rigid exterior insulation as hereinafter specified.
- F. Contractor-applied internal linings shall be as specified and installed as hereinafter specified.
- G. For exposed Fiberglass duct insulation, tightly butt all edges and seams. Secure insulation with flush mechanical fasteners spaced not less than one per square foot. Insulation may be secured with 100 percent coverage of adhesive with mechanical fasteners on the underside of the duct only, in addition to adhesive. Adhesive shall be water based Foster 85-60 or Childers CP-127. Cover all seams, joints and fasteners with not less than 3-inch wide tape matching the insulation facing. Pre-finished white fastener caps may be left

exposed if the spacing and pattern is uniform in appearance. Staples will not be permitted.

- H. All dual wall exterior ductwork shall be insulated with 2-inch rigid type 6.0 pcf minimum density, .25 max "K" factor with white vinyl A.S.J. vapor barrier facing. Insulation shall be sandwiched between inner galvanized ductwork and exterior aluminum ductwork.
- I. All disturbed ductwork insulation in existing areas shall be re-insulated with insulation type and thickness as specified for new ductwork. Duct insulation damaged due to installation of new work and demolition only shall be replaced.
- J. All supply air diffusers and supply air registers shall be fully insulated on the rear exposed surface to prevent condensation. Insulation shall be 1 ½" inch flexible blanket type 1 ½ pcf minimum density with reinforced foil-scrim-Kraft vapor barrier facing, .25 max "k" factor.
- K. All airflow monitoring stations shall be externally insulated similar to adjacent ductwork as hereinbefore specified.

2.6. ACCESSORY MATERIALS

- A. Accessory materials installed as part of insulation work under this section shall include, but not be limited to:
 - 1. Closure Materials - Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.
 - 2. Field-applied jacketing materials - sheet metal, plastic, canvas, fiber glass cloth, insulating cement; PVC fitting covers, PVC jacketing.
 - 3. Support Materials - Hanger straps, hanger rods, saddles.
 - 4. Fasteners, weld pins/studs, speed clips, insulation washers.
 - 5. Metal mesh or expanded metal lagging.
- B. All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Insulation Standards."
- C. At all static pressure measurement points and pitot tube traverse points install inspection plugs as manufactured by Inspection Plug Strategies. Inspection plugs shall be installed in ductwork per manufacturer's requirements and shall be located where indicated by the Test/Balance Engineer. The inspection plugs shall comply with the following:
 - 1. 50 Durometer EPDM Rublen rated for 340°F.
 - 2. Temperature resistant range= -67°F to 340°F.
 - 3. U.V. resistant.

4. Ozone resistant.
5. Comply with ASTM D470 0624 D2132 D865 D395. Furnish each inspection plug with EPDM sealing flange, EPDM cap, and stainless steel attached lanyard.
6. Provide waterproof label identifying all inspection plugs.

2.7. HANGER BLOCKS

- A. For all pipes larger than 3 inches in diameter the hanger blocks shall be high compressive strength foam or wood blocks. Wood blocks shall be precision cut thickness to match specified insulation and shall include flared edge hanger saddle as manufactured by Buckaroo.
- B. The wood blocks shall be suitable for temperatures from -120 degrees Fahrenheit to 200 degrees Fahrenheit. Do not utilize the wood blocks for piping systems operating outside of the indicated temperature range.
- C. Wood blocks are not acceptable for use at refrigerant pipe hangers.

PART 3. EXECUTION

3.1. WORKMANSHIP

- A. The Contractor shall take special care to prevent soiling equipment below or adjacent to areas being insulated. He shall be completely responsible for removing insulation cement splashes and smears and all surfaces that he mars or otherwise soils or defaces, and he will be totally responsible for restoring these damaged surfaces to their like-new condition when delivered to the site.

3.2. SITE INSPECTION

- A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.
- B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.
- C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.3. PREPARATION

- A. Ensure that all pipe and equipment surfaces over which insulation is to be installed are clean and dry.
- B. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation

shall not be acceptable for installation.

- C. Ensure that pressure testing of piping or duct systems has been completed prior to installing insulation.

3.4. INSTALLATION

A. Piping Systems

1. General:

- a. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
- b. Install insulation on piping subsequent to installation of heat tracing, painting, testing, and acceptance tests.
- c. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.
- d. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tear or other damage. Seal all tears, punctures and other penetrations of the pipe insulation vapor barrier coating.
- e. On exposed piping, locate insulation and cover seams in least visible location.

2. Fittings: Cover valves, fittings, unions, flanges, strainers, flexible connections, expansion joints, pump bodies, strainers, blowdowns, backflow preventers, autoflow valves and similar items in each piping system using one of the following:

- a. Mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs.
- b. Cold pipe fittings: Apply a tack coat of vapor barrier coating and reinforcing mesh to produce a smooth surface. After ½ hour, apply a second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping.
- c. Hot pipe fittings and Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of Type C or Type H breather mastic over the reinforcing cloth, working it to a smooth finish.
- d. Insulation cement equal in thickness to the adjoining insulation.
- e. PVC fitting covers insulated with material equal in thickness and composition to adjoining insulation.

3. Penetrations: Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise specified.

4. Joints:

- a. Butt pipe insulation against hanger inserts. For hot pipes, apply 3-inch (7.5cm) wide vapor barrier tape or bank over butt joints. For cold piping, apply wet coat of vapor barrier lap cement on butt joints, and seal joints with 3-inch (7.5cm) wide vapor barrier tape or band.
- b. All pipe insulation ends shall be tapered and sealed, regardless of service.

B. Equipment Insulation:

1. General:

- a. Install insulation in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
- b. Install insulation on equipment after installation of heat tracing, painting, testing, and acceptance tests.
- c. Install insulation materials with smooth, even surfaces. Rework poorly fitted joints. Do not use joint sealer or mastic as filler for joint gaps and excessive voids resulting from poor workmanship. Apply insulation using staggered joint method for both single and double layer installation, applying each layer of insulation separately.
- d. Coat insulated surfaces where specified on contract drawings with layer of insulating cement, troweled in a workmanlike manner, leaving a smooth and continuous surface. Fill in seams, broken edges, and depressions. Cover over wire mesh and joints with cement sufficiently thick to remove surface irregularities.
- e. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. Seal all tears, punctures and other penetrations of equipment insulation facing.
- f. Where specification calls for field-applied all-service vapor barrier jacketing, it shall be neatly fitted and tightly secured. Lap seams 2-inches (5cm) (min.). Seal all joints with adhesive. Tape with 3-inches (7.5cm) matching pressure-sensitive tape or 3-inch (7.5cm) glass fabric and vapor barrier coating.
- g. On exposed equipment, locate insulation and cover seams in least visible location.

2. Removable Insulation: Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance, such as vessel covers, fasteners, flanges, frames accessories, manholes, handholes, cleanouts ASME stamp, and manufacturer nameplates.

3. Areas Left Uninsulated: Items such as boiler manholes, handholes, clean-outs, ASME stamp, and manufacturers' nameplates should be left uninsulated unless omitting insulation would cause a condensation problem. When such is the case, provide removable insulation and appropriate tagging to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

4. Equipment Exposed to Weather: Protect outdoor insulation from weather by

installation of weather barrier mastic protective finish or jacketing as recommended by the jacketing manufacturer.

C. Ductwork Insulation:

1. General:

- a. Before installing insulation, ensure that all seams and joints in ductwork have been sealed and leak tested by the contractor responsible for the duct system. Before applying duct insulation, air ducts shall be clean and dry.
- b. Install insulation in accordance with manufacturer's published instructions and recognized industry practice to ensure that it will serve its intended purpose.
- c. Install insulation materials with smooth and even surfaces. Butt joints firmly together to ensure complete and tight fit over surfaces to be covered.
- d. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. All staples used on ductwork insulation shall be coated with suitable sealant to maintain vapor barrier integrity and covered with pressure sensitive vapor barrier tape and vapor barrier coating as specified.
- e. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and exposed joints. All portions of duct designated to receive duct wrap shall be completely covered with duct wrap.
- f. To ensure installed thermal performance, duct wrap insulation shall be cut to "stretch-out" dimensions. Maintain specified duct insulation thickness and vapor barrier at all fittings, obstructions, and duct flanges.
- g. A 2-inch (50mm) piece of insulation shall be removed from the facing at the end of the piece of duct wrap to form an overlapping stapling and taping flap.
- h. Install duct wrap insulation with facing outside so that the tape flap overlaps the insulation and facing at the other end of the piece of duct wrap. Adjacent sections of duct wrap insulation shall be tightly butted with the 2-inch (50mm) stapling and taping flap overlapping. If ducts are rectangular or square, install so insulation is not excessively compressed at corners. Seams shall be stapled approximately 6-inches (150mm) on center with 2-inch (13mm) (min) steel outward clinching staples.
- i. Seams, joints and staples shall be sealed with pressure-sensitive tape matching the insulation facing (either plain foil or FRK backing stock) and glass fabric and vapor barrier coating. Cloth duct tape of any color or finish using reclaimed rubber adhesives shall not be utilized on duct wrap insulation. Adjacent sections of duct wrap shall be tightly butted with the 2-inch (50mm) tape flap overlapping.
- j. Where rectangular ducts are 24-inch (600mm) in width or greater, duct wrap insulation shall be additionally secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers, spaced on 18-inch (425mm) centers (maximum) to prevent sagging of insulation.
- k. Seal all tears, punctures and other penetrations of the duct wrap facing using one of the above methods to provide a vapor tight system.
- l. Upon completion of installation of duct wrap and before operation is to commence, visually inspect the system and verify that it has been correctly

- installed.
 - m. Open all system dampers and turn on fans to blow all scraps and other loose pieces of material out of the duct system. Allow for a means for removal of such material.
 - n. Check the duct system to ensure that there are no air leaks through joints.
 - o. No ductwork insulation shall be supported utilizing tie wire or bailing wire. Penetrations of ductwork insulation vapor barrier are prohibited.
 - p. Bevel and terminate insulation at access doors. Paint edges with vapor barrier mastic.
 - q. Install insulation board between volume dampers and sheet metal standoffs.
 - r. Provide removable insulation section at all pitot tube traverse points. Insulation section shall contain tether that attaches to adjacent ductwork.
- 2. Penetrations: Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise specified.
 - 3. Ductwork Exposed to Weather: Protect outdoor insulation from weather by installing outdoor weather barrier mastic or jacketing as recommended by the insulation manufacturer.
 - 4. Rigid Insulation:
 - a. Rigid duct insulation may be impaled over welded pins and secured with insulation caps and washers matching the color of the vapor barrier facing. All seams shall be firmly butted and sealed with pressure-sensitive vapor barrier tape matching the facing and vapor barrier coating.
 - b. Corner angles shall be installed on all external corners of rigid duct insulation in exposed finished areas before jacketing, except oven and hood exhaust duct insulation, which shall have no corner angles.
 - 5. Duct Wrap Insulation: Duct wrap insulation shall be applied with all joints butted firmly together. All joints in the insulation covering shall be sealed with adhesive. Duct wrap insulation shall be secured to bottom of rectangular or oval ducts over 24inches (60cm) wide with mechanical fasteners on 16-inch (40 cm) (approx.) centers to prevent sagging.
 - 6. Duct Lining Insulation: Duct liner insulation shall be applied with all joints tightly butted using 90 percent coverage of adhesive meeting the requirements of ASTM C 916 plus mechanical fasteners spaced according to the liner manufacturer's schedule for the interior width of the plenum, housing, or air shaft. (Also refer to Division 23 Section, HVAC Air Distribution System.)

3.5. FIELD QUALITY ASSURANCE

- A. Upon completion of all insulation work covered by this specification, visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

3.6. PROTECTION

- A. Replace damaged insulation which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.
- B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.7. SAFETY PRECAUTIONS

- A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.
- B. The insulation contractor shall conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

3.8. INSULATION COVERING

- A. Unless otherwise noted, all exposed duct and equipment insulation shall have a field applied PVC jacket cover neatly cut and pasted over ductwork and equipment insulation. PVC shall be high gloss white and shall be 20 mils thick.
- B. Unless otherwise noted, all exposed pipe insulation required to be insulated shall be jacketed with a PVC Jacketing with fitting covers. PVC jacket shall be color fade resistant, white high gloss, U.S.D.A. authorized as manufactured by Proto Corporation or approved equal. PVC jacketing shall be high impact, ultraviolet resistant PVC. Minimum thickness shall be 20 mils, roll stock ready for shop or field cutting and forming.
- C. Exposed areas include, but are not limited to, all mechanical equipment rooms/fan rooms, mezzanines, penthouses, boiler rooms, kitchens, electric rooms, piping and ductwork exposed in an occupied space.
- D. Where PVC jackets are indicated, install with 1 inch overlap at longitudinal seams and end joints, for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- E. Exterior exposed pipe insulation required to be insulated shall be jacketed with a corrugated aluminum jacketing system as previously described. Seal all laps with 1/8" bead metal jacketing sealant.

END OF SECTION

DIVISION 23 SECTION 23 09 00
INSTRUMENTATION AND CONTROLS OF HVAC AND PLUMBING SYSTEMS
TABLE OF CONTENTS

PART 1. GENERAL.....	3
1.1. SUMMARY.....	3
1.2. DEFINITIONS	5
1.3. SYSTEM PERFORMANCE	6
1.4. DELIVERY, STORAGE, AND HANDLING.....	6
1.5. COORDINATION.....	7
1.6. WORK BY OTHERS	7
1.7. QUALITY ASSURANCE.....	7
1.8. GUARANTEE AND INSTRUCTION.....	8
1.9. SUBMITTALS	9
1.10. SOFTWARE LICENSE AGREEMENT	11
1.11. ELECTRICAL SURGE PROTECTION	11
1.12. TRAINING.....	11
1.13. ALTERNATES	12
1.14. GLOBAL SENSORS.....	12
PART 2. PRODUCTS.....	13
2.1. BUILDING MANAGEMENT SYSTEM.....	13
2.2. WIRING	25
2.3. CONTROLLERS.....	26
2.4. DAMPERS	26
2.5. HYDRONIC CONTROL VALVES (GEOTHERMAL ROOFTOP UNIT).....	28
2.6. PRESSURE INDEPENDENT HYDRONIC CONTROL VALVES (HEATING WATER VALVES)	29
2.7. CONTROL PANELS	33
2.8. MISCELLANEOUS ELECTRICAL DEVICES	33
2.9. UNINTERRUPTIBLE POWER SUPPLY	33
2.10. DESKTOP WORKSTATIONS	34
2.11. CENTRAL CONTROL AND MONITORING SYSTEM (CCMS) (HARDWARE DESCRIPTION).....	36
2.12. HEAT PUMP CONTROLLER.....	49
2.13. SYSTEM SOFTWARE DESCRIPTION	49
2.14. EXCEPTION REPORTING SEQUENCES.....	50
2.15. MONITORING SYSTEM, SENSORS AND WIRING	50
2.16. MAKE-UP WATER FLOW METER/ALARM	53
2.17. FLOW MEASURING STATIONS	54
2.18. FIELD INSTALLED CONDENSATE OVERFLOW SWITCHES	54
2.19. CO2 SENSORS/TRANSMITTER	54
PART 3. EXECUTION.....	55
3.1. GENERAL.....	55
3.2. BMS SPECIFIC REQUIREMENTS	55
3.3. WORKSTATION INSTALLATION	55
3.4. INSTALLATION & SUPERVISION	56
3.5. ACCEPTANCE TESTING.....	57

3.6.	VARIABLE AIR VOLUME AIR BALANCING	58
3.7.	COORDINATE WITH TAB AGENCY	58
3.8.	EXAMINATION.....	59
3.9.	INTERLOCK REQUIREMENTS.....	59
3.10.	SUBMITTALS AT PROJECT CLOSEOUT.....	59
3.11.	CONNECTIONS.....	59
3.12.	FIELD QUALITY CONTROL.....	60
3.13.	ADJUSTING	61
3.14.	ON-SITE ASSISTANCE.....	62
3.15.	SCHEDULING.....	62
3.16.	STAGING.....	62
3.17.	VRF/VRV SYSTEMS INTEGRATION	62

SECTION 23 09 00**INSTRUMENTATION AND CONTROLS OF HVAC AND PLUMBING SYSTEMS****PART 1. GENERAL****1.1. SUMMARY**

- A. For General Mechanical Requirements, see Division 23 Section, Common Work Results for HVAC, and Division 01 Sections.
- B. Comply with all code requirements and fire safety requirements as specified in Division 23 Section, Common Work Results for HVAC.
- C. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- D. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory wired controls.
- E. The automatic temperature control system ATC and central control and monitoring system (CCMS) shall be electric/electronic direct digital control (DDC), Johnson Controls FX as installed by Modern Controls, or Trane. All work associated with the automatic temperature control system shall be performed by personnel regularly and directly employed by the Automatic Temperature Controls Contractor. Control System shall be web based, allowing the client access via a standard web browser.
- F. Coordinate controls with controlled equipment. Upon completion of the work, calibrate and adjust all controls for proper function. Electric wiring, including interlock wiring for equipment such as air handlers, fans, switches, heat pumps, ERV's, pumps, variable refrigerant volume systems, rooftop geothermal heat pumps, unit heaters, condensing units, etc., shall be furnished and installed under this section. All electrical work shall conform to the applicable requirements of Division 26.
- G. All automatic temperature control dampers, valves and separable wells for immersion elements furnished by the Control Manufacturer shall be installed by the Mechanical Contractor or his sheet metal subcontractor under the Control Manufacturer's supervision.
- H. Reference is hereby made for this contractor to become familiar with Division 26 of these specifications. Familiarization is for coordination purposes only. The control contractor shall provide all necessary relays, contacts, interlock wiring etc. not provided under Division 26 for the automation of the ATC and CCMS systems as required by the sequence of operation and input/output schedule. The control contractor shall coordinate all requirements with the building Fire Alarm System. The control contractor shall provide all additional devices and interlock wiring required for the automation of the ATC system and monitoring of the CCMS system.
- I. Furnish all labor, materials, software, equipment and services necessary for and incidental to furnishing and installing a complete direct digital control, automatic temperature control

system to meet the requirements of the sequence of operation described on the Drawings.

- J. Unless the necessary items are specified to be provided with mechanical equipment by Division 23, the ATC contractor shall coordinate with Division 23, Mechanical, and shall furnish and install all items necessary to meet the requirements of the Sequence of Operation and the Central Control and Monitoring System (CCMS) indicated on the drawings and as required in this specification.
- K. The control system shall include all necessary and specified control equipment properly installed in accordance with the specifications and drawings and shall include, but not be limited to the automatic temperature control and energy management system of the following:
 - 1. Airflow Monitoring Stations
 - 2. Automatic Glycol Feeder
 - 3. Building Facilities
 - 4. Carbon Dioxide Sensors
 - 5. Condensing Units
 - 6. Condenser Water Pumps
 - 7. Differential Bypass Valves
 - 8. Domestic Hot Water Systems
 - 9. Ductless Units
 - 10. Duct Detector Fan Interlocks
 - 11. Energy Recovery Ventilators
 - 12. Elevator Sump Pumps
 - 13. Exterior Lighting Systems
 - 14. Flow Measuring Stations
 - 15. Flow Switches
 - 16. Freeze Protection Pumps
 - 17. General Exhaust Systems
 - 18. Glycol Feed Systems
 - 19. Geothermal Heat Pumps
 - 20. Heating System

21. High Temperature Alarms
 22. Hot Gas Re-heat Coils
 23. Lighting Systems
 24. Make-up Water Systems Interlocks and Alarms
 25. Mechanical Room Heat and Ventilation Control
 26. Miscellaneous interlocks required for gas systems, ventilation systems, etc.
 27. Plumbing Systems
 28. Pumps
 29. Rooftop Units.
 30. Unit Heater Control
 31. Variable Speed Drives
 32. Ventilation Systems
 33. Variable Refrigerant Volume Systems
- L. All labor, material, equipment and software to meet the functional intent of the system, as specified herein and as shown on the drawings, shall be included. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans, that are required to meet the functional intent, shall be provided without additional cost to the owner.
- M. Where equipment is specified to be provided by equipment manufacturer or where packaged controls are specified map out all points provided by the manufacturer so the same can be viewed by ATC system. As a minimum all points indicated in the point list and control diagram must be viewable and adjustable from the ATC system. Coordinate with equipment manufacturer.

1.2. DEFINITIONS

- A. DDC: Direct digital control.
- B. I/O: Input/output.
- C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- D. MS/TP: Master slave/token passing.
- E. PC: Personal computer.

- F. PID: Proportional plus integral plus derivative.
- G. RTD: Resistance temperature detector.
- H. UPS: Uninterruptible Power Supply.
- I. NAE: Network Automated Engine.

1.3. SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
 - 1. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 - 2. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
 - 3. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
 - 4. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - 5. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
 - 6. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
 - 7. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
 - b. Water Flow: Plus or minus 5 percent of full scale.
 - c. Water Pressure: Plus or minus 2 percent of full scale.
 - d. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
 - e. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
 - f. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
 - g. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
 - h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
 - i. Relative Humidity: Plus or minus 5 percent.
 - j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
 - k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
 - l. Airflow (Terminal): Plus or minus 10 percent of full scale.
 - m. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
 - n. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
 - o. Carbon Dioxide: Plus or minus 50 ppm.
 - p. Electrical: Plus or minus 5 percent of reading.

1.4. DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.

1.5. COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment with Division 28 Section, "Fire Alarm System" to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.
- D. Coordinate equipment with Division 26 Section, Electricity Metering to achieve compatibility of communication interfaces.
- E. Coordinate equipment with Division 26 Section, Panelboards to achieve compatibility with starter coils and annunciation devices.
 - 1. Coordinate equipment with Division 26 Section, Motor-Controllers to achieve compatibility with motor starters and annunciation devices.

1.6. WORK BY OTHERS

- A. Automatic temperature control valves, air flow stations, pipe taps, flow meters, and separable wells for immersion elements furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision. The control contractor shall deliver to the mechanical contractor valves and wells for installation within the various systems.
- B. All automatic dampers furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision.

1.7. QUALITY ASSURANCE

- A. The automatic temperature control (ATC) system and the central control and monitoring system (CCMS) shall be as manufactured by Johnson Controls FX as installed by Modern Controls or Trane shall be an acceptable installer of the ATC system.
- B. Supplier shall have an in-place support facility with technical staff, spare parts inventory and all necessary test and diagnostic equipment. The fully staffed and equipped office shall be within a 60 mile radius of the job site.
- C. The systems shall be complete in all respects, and shall be installed by skilled personnel. The Control Contractor shall have a successful history in the installation and maintenance of automatic temperature control systems similar in size and performance to that specified

herein.

- D. All electrical wiring in connection with the Automatic Temperature Control System shall be furnished and installed by the ATC Contractor. This shall include all interlock wiring between the air handling units, fans, pumps, heating systems, boilers, switches, VAV boxes, dampers, heat pumps, energy recovery ventilators, geothermal units, ductless units, condensing units, static pressure controllers, variable refrigerant volume systems, single zone VAV units, etc.
- E. Bids by wholesalers, contractors or franchised dealers or any other firm whose principal business is not that of manufacturing or installing automatic temperature control systems, shall not be acceptable. Bid documents that are not complete in their response to these documents or take exception to any of the capabilities defined within these documents shall not be acceptable.
- F. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.
- G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- H. Comply with ASHRAE 135 for DDC system components.

1.8. GUARANTEE AND INSTRUCTION

- A. The control system including all components, system software, parts and assemblies herein specified shall be free from defects in workmanship and materials under normal use and service. After completion of the installation, the Control Manufacturer shall regulate and adjust all thermostats, control valves, control motors, and other equipment provided under this contract. If within two (2) years from the date of acceptance by Owner any of the equipment herein described is proved to be defective in workmanship or materials, it will be replaced or repaired at no additional cost to the Owner. The Control Manufacturer shall, after completion, provide any service incidental to the proper performance of the Control System under guarantees outlined above for a period of two (2) years. Normal maintenance of the system is not to be considered part of the guarantee. All corrective modifications made during warranty service periods shall be updated on all user documentation including "as-built" shop drawings and on user and manufacturer archived software disks.
- B. The control contractor shall completely check out, calibrate and test all connected hardware to insure that the system performs in accordance with the approved specifications and sequences of operation submitted.
- C. Upon completion of the work, the control drawings encased in heavy plastic shall be provided where directed. Layout shall show all control equipment and the function of each item indicated.
- D. The temperature control contractor's office shall be within a 100 mile radius of the job site.
- E. The contractor shall respond to the job site with qualified technicians within a 4 hour period

for any emergency relating to the control system or energy management systems.

- F. This agreement shall include emergency service during normal working hours.

1.9. SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
 3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
 2. Schematic flow diagrams showing equipment, fans, pumps, coils, dampers, valves, and control devices.
 3. Wiring Diagrams: Power, signal, and control wiring.
 4. Details of control panel faces, including controls, instruments, and labeling.
 5. Written description of sequence of operation.
 6. Schedule of dampers including size, leakage, and flow characteristics.
 7. Schedule of valves including flow characteristics.
 8. DDC System Hardware:
 - a. Wiring diagrams for control units with termination numbers.
 - b. Schematic diagrams and floor plans for field sensors and control hardware.
 - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:
 - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
 - c. Written description of sequence of operation including schematic diagram.
 - d. Points list.
- C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks or Bacnet.
- D. Software and Firmware Operational Documentation: Include the following:
 1. Software operating and upgrade manuals.
 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.
 5. Software license required by and installed for DDC workstations and control systems.
- E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
- F. Qualification Data: For Installer and manufacturer.
- G. Field quality-control test reports.
- H. Submit screen shots of ATC system graphics at substantial completion.
- I. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section, Operation and Maintenance Data, and Division 23 Section, Common Work Results for HVAC include the following:
 1. Maintenance instructions and lists of spare parts for each type of control device.
 2. Interconnection wiring diagrams with identified and numbered system components and devices.
 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.

4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 5. Calibration records and list of set points.
- J. Upon completion of the work, provide a complete set of "as-built" drawings and application software on CD, USB, or other type of electronic storage device. Drawings shall be provided in format as acceptable to the Owner's files. Submit as-built drawings and specification to Owner's representative for review and approval prior to final project closeout.

1.10. SOFTWARE LICENSE AGREEMENT

- A. The owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.
- B. Software license agreement shall not apply on projects where existing ATC system is being extended.

1.11. ELECTRICAL SURGE PROTECTION

- A. It is the responsibility of the ATC/FMS contractor to provide adequate surge protection for all wall mounted control panels required for this project.
1. Devices under surge protection shall be of design that loss of memory will not occur in the event of the surge protection device being activated due to surge/spike conditions.
 2. Surge protection devices will be required to be hard wired, with the exception of peripheral devices that use standard 110VAC plugs for connections (i.e. Modems).
 3. Surge protection devices are to be rated for 120 VAC single phase, 20 (or greater) amps capacity.
 4. Surge Protection devices to include internal fuse protection, audible surge alarm & LED indicators.
 5. Surge protectors to have clamping voltage of 480V peak, maximum surge current rating of 50,000 amps. Unit to have NEMA 12 enclosure with wall mounting bracket and conduit connection.

1.12. TRAINING

- A. The Automatic Temperature Controls (ATC) Contractor shall include in his bid, provisions for additional computer training at the company's regular school or training center. The ATC contractor shall include in his bid all costs associated with sending one (1) individual to the ATC contractors school for a period of not less than one (1) weeks. This training is in addition to the aforementioned training required under the General Provisions.

- B. The training time period shall be coordinated with the school system's facility Engineer. The schedule training period shall be arranged at the owner's convenience.
- C. Cost shall include all training material, instruction books, and two copies of video tape with sound DVD of training session.
- D. Upon completion of the work, the Control Contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on the operation of the control system for a period of not less than (8) hours. All training shall be by the control contractor and shall utilize specified manuals and as-built documentation.
- E. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
 - 2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.
 - 3. Review data in maintenance manuals. Refer to Division 01 Section, Contract Closeout.
 - 4. Review data in maintenance manuals. Refer to Division 01 Section, Operation and Maintenance Data.
 - 5. Schedule training with Owner, through Architect, with at least seven days' advance notice.

1.13. ALTERNATES

- A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

1.14. GLOBAL SENSORS

General

- 1. Furnish and install global sensors and report the same on the automatic temperature control system.
- 2. Global sensors shall monitor and trend the following conditions:
 - a. Outside air temperature.
 - b. Outside air humidity.
 - c. Heating water supply water temperature.
 - d. Heating water return water temperature.
 - e. All ventilation fan speeds where variable frequency drives are specified.
 - f. Outside air carbon dioxide level.

- g. All ventilation fan amperage where variable frequency drives are specified.
- h. All pump or fan speeds where variable frequency drives are specified.
- i. All pump amperage's where variable frequency drives are specified.
- j. All fan amperages where variable speed fans are indicated. Graphic shall also indicate area of building served by each item of equipment.
- k. Main Distribution Frame (MDF), and I.T. server room space temperature sensor.
- l. Global holiday schedules:
 - i. Provide all interlock wiring and programming to allow a global holiday schedule for all equipment except the administration equipment. Global holiday schedule shall allow the Owner to shut down the entire school's HVAC systems if an unscheduled event occurs when school is cancelled.
 - ii. System shall also be capable of individual scheduling of equipment as specified or all can be globally modified at once.
- m. All equipment interlocked with ATC system shall be able to be turned on/off via ATC system as specified. Changing temperature set point alone is not acceptable method for turning equipment on/off.
- n. Where valve or damper position is indicated ATC graphic shall indicate percentage open or percentage closed.

PART 2. PRODUCTS

2.1. BUILDING MANAGEMENT SYSTEM

- A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.
- B. The Building Management System shall consist of the following:
 - 1. Standalone Network Automation Engine(s)
 - 2. Field Equipment Controller(s)
 - 3. Input/Output Module(s)
 - 4. Local Display Device(s)
 - 5. Portable Operator's Terminal(s)
 - 6. Distributed User Interface(s)
 - 7. Network processing, data storage and communications equipment
 - 8. Other components required for a complete and working BMS

- C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
- E. Acceptable Manufacturers
 - 1. Johnson Controls, Reliable, Siemens, Honeywell, Automated Logic Cooperation, Schneider Electric, Advanced Power, Trane, Alerton, Niagara, or TAC Controls by Schneider Electric.
- F. Automation Network
 - 1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard “off the shelf” products available through normal PC vendor channels.
 - 2. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
 - 3. Network Automation Engines (NAE) and/or system controllers shall reside on the automation network.
 - 4. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.
- G. Control Network
 - 1. Network Automation Engines and/or system controllers shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:
 - a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
 - b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).
 - c. Tridium FX-40
 - d. Trane
 - 2. Control networks shall provide either “Peer-to-Peer,” Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
 - 3. DDC Controllers shall reside on the control network.
 - 4. Control network communication protocol shall be BACnet Standard MS/TP Bus

Protocol ASHRAE SSPC-135.

5. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.
6. The Conformance Statements shall be submitted 10 day prior to bidding.

H. Integration

1. Hardwired
 - a. Analog and digital signal values shall be passed from one system to another via hardwired connections.
 - b. There will be one separate physical point on each system for each point to be integrated between the systems.
2. BACnet Protocol Integration – BACnet
 - a. The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2003.
 - b. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.
 - c. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

I. Dedicated Web Based User Interface

1. Where required by the Owner, the BMS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines to facilitate greater fault tolerance and reliability. Coordinate with Owner to determine computer type (i.e. PC (Windows based) or Macintosh (Apple)).
2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards.
 - a. Microsoft Internet Explorer for user interface functions
 - b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions
 - c. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports
 - d. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system

summaries.

3. Computer Hardware – The personal computer(s) shall be configured as follows:
 - a. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.
 - b. Performance Requirements:
 - i. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 - ii. Energy Star compliant.
 - c. Personal Computer:
 - i. Minimum Processor Speed: 3 gigahertz (GHz).
 - d. RAM:
 - i. Capacity: 8GB.
 - ii. Speed and Type: 1333 MHz, SDRAM.
 - e. Hard Drive:
 - i. Media: Solid state.
 - ii. Number of Hard Drives: One.
 - iii. Capacity: 250GB.
 - f. Optical Read and Write Drive:
 - i. Include with at least 2 MB of data buffer.
 - ii. Type: SCSI CD-ROM Drive with Read/Write Capability.
 - iii. Average access time of 150 ms or less.
 - g. At least four expansion slots.
 - h. Video Card:
 - i. Resolution: 1920 by 1200 pixels.
 - ii. RAM: 4 GB.
 - iii. Controller Speed: 4GHz.
 - i. Sound Card:
 - i. At least 128 voice wavetable synthesis.
 - ii. Capable of delivering three-dimensional sound effects.
 - iii. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
 - j. Network Interface Card: Include card with connection, as applicable.
 - i. 10-100-1000 base TX Ethernet with RJ45 connector port.
 - ii. 100 base FX Ethernet with SC or ST port.
 - k. Wireless Ethernet, 802.11 a/b/g/n.
 - l. Optical Modem: Full duplex link for connection to optical fiber cable provided.
 - m. I/O Ports:
 - i. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
 - ii. One serial port.
 - iii. One parallel port.
 - iv. Two PS/2 ports.
 - v. One RJ-45.
 - vi. One stereo line-in and headphone/line-out on back panel.
 - vii. One microphone and headphone connector on front panel.
 - viii. One IEEE 1394 on front and back panel with PCI-e card.
 - ix. One ESATA port on back panel.
 - n. Battery: Life of at least three years to maintain system clock/calendar and

- ROM, as a minimum.
- o. Keyboard:
 - i. 101 enhanced keyboard.
 - ii. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
 - iii. Wireless operation within up to 72 inches (1800 mm) in front of workstation.
- p. Pointing Device:
 - i. Either a two- or three-button mouse.
 - ii. Wireless operation within up to 72 inches (1800 mm) in front of workstation.
- q. Flat Panel Display Monitor:
 - i. Display:
 - 1. Color display with 21 inches diagonal viewable area.
 - 2. Digital input signal.
 - 3. Aspect Ratio: 16 to 9.
 - 4. Antiglare display.
 - 5. Tilt adjustable base.
 - 6. Energy Star compliant.
 - 7. Resolution: 1920 by 1200 pixels at 60 Hz.
 - 8. Number of Displays: One.
- r. Speakers:
 - i. Two, with individual controls for volume, bass and treble.
 - ii. Signal to Noise Ratio: At least 65 dB.
 - iii. Power: At least 4 W per speaker/channel.
 - iv. Magnetic shielding to prevent distortion on the video monitor.
- s. I/O Cabling: Include applicable cabling to connect I/O devices.

J. User Interface Application Components

1. Operator Interface

- a. An integrated browser based client application shall be used as the user operator interface program.
- b. All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3 or on the drawings, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.
- c. The user interface software shall provide help menus and instructions for each operation and/or application.
- d. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.
- e. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
 - i. User access for selective information retrieval and control command execution
 - ii. Monitoring and reporting

- iii. Alarm, non-normal, and return to normal condition annunciation
- iv. Selective operator override and other control actions
- v. Information archiving, manipulation, formatting, display and reporting
- vi. FMS internal performance supervision and diagnostics
- vii. On-line access to user HELP menus
- viii. On-line access to current FMS as-built records and documentation
- ix. Means for the controlled re-programming, re-configuration of FMS operation and for the manipulation of FMS database information in compliance with the prevailing codes, approvals and regulations for individual FMS applications.
- x. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

2. Navigation Trees

- a. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.
- b. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.
- c. The navigation trees shall be “dockable” to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.

3. Alarms

- a. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
 - i. Log date and time of alarm occurrence.
 - ii. Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.
 - iii. Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
 - iv. Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
 - v. Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers

- as the exclusive means of annunciating alarms are not acceptable.
 - vi. Any attribute of any object in the system may be designated to report an alarm.
 - b. The FMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions
 - c. The FMS shall annunciate application alarms as required.
- 4. Reports and Summaries
 - a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:
 - i. All points in the BMS
 - ii. All points in each BMS application
 - iii. All points in a specific controller
 - iv. All points in a user-defined group of points
 - v. All points currently in alarm
 - vi. All points locked out
 - vii. All BMS schedules
 - viii. All user defined and adjustable variables, schedules, interlocks and the like.
 - b. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
 - c. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.
 - d. The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.
- 5. Schedules
 - a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
 - i. Weekly schedules
 - ii. Exception Schedules
 - iii. Monthly calendars
 - b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
 - c. It shall be possible to define one or more exception schedules for each schedule including references to calendars
 - d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.
 - e. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.
 - f. Schedules and Calendars shall comply with ASHRAE SP135/2003

- BACnet Standard.
 - g. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.
- 6. Password
 - a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.
 - b. Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.
 - c. The system shall allow each user to change his or her password at will.
 - d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
 - e. A minimum of five levels of access shall be supported individually or in any combination as follows:
 - i. Level 1 = View Data
 - ii. Level 2 = Command
 - iii. Level 3 = Operator Overrides
 - iv. Level 4 = Database Modification
 - v. Level 5 = Database Configuration
 - vi. Level 6 = All privileges, including Password Add/Modify
 - f. A minimum of 100 unique passwords shall be supported.
 - g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
 - h. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.
- 7. Screen Manager - The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.
- 8. Dynamic Color Graphics
 - a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
 - b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
 - c. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.

- d. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
 - i. All graphics shall be fully scalable
 - ii. The graphics shall support a maintained aspect ratio.
 - iii. Multiple fonts shall be supported.
 - iv. Unique background shall be assignable on a per graphic basis.
 - v. The color of all animations and values on displays shall indicate the status of the object attribute.
 - e. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device
 - f. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.
 - i. The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
 - ii. In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.
 - g. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.
9. Historical trending and data collection
- a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
 - i. Any point, physical or calculated, may be designated for trending. Two (2) methods of collection shall be allowed:
 - 1. Defined time interval
 - 2. Upon a change of value.
 - ii. Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.
 - b. Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time scheduled basis.
10. Trend data viewing and analysis

- a. Provide a trend viewing utility that shall have access to all database points.
- b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
- c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
- d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
- e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
- f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
- g. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

K. Portable Operator Terminal

1. For systems that do not provide full access to systems configuration and definition via the Browser Based user interface the BMS Contractor shall provide a portable operator terminal for programming purposes. The terminal shall be configured as follows:
 - a. Personal Laptop Computer Manufacturer – Dell, Compaq or HP
 - b. 1 GB RAM (256 MB minimum) – Windows 2000 or XP Professional.
 - c. 1.8 GHz Clock Speed Pentium 4 Microprocessor (800 MHz minimum).
 - d. 40 GB Hard Drive. (40 GB minimum)
 - e. (1) CD-ROM Drive, 32x speed.
 - f. (1) Serial (1) Parallel (2) USB ports
 - g. 1 Keyboard with 83 keys (minimum).
 - h. Integral 2 button Track Point or Track Ball.
 - i. 10" SVGA 1024x768 resolution color display
 - j. Two PCMCIA Type II or one Type III card slot.
 - k. Complete operator workstation software package, including any hardware or software.
 - l. Original printed manuals for all software and peripherals.
 - m. Original installation disks or CD for all software, device drivers, and peripherals.
 - n. Software registration cards for all included software shall be provided to the Owner.
 - o. Carrying case.
 - p. Spare battery.
 - q. External power supply/battery charger.
2. Proprietary Portable Terminal
 - a. Manufacturers providing proprietary portable terminals shall submit technical data sheets for the terminal and all associated software and hardware.
 - b. The proprietary terminal shall meet the same operator interface software

requirements as specified above.

3. Software

- a. Portable operator terminals shall support all controllers within the system on a direct-connect communications basis.
- b. When used to access First or Second Tier controllers, the portable operator terminal shall utilize the standard operator workstation software, as previously defined.
- c. When used to access Application Specific Controllers, the portable operator terminal shall utilize either the standard operator workstation software, as previously defined, or controller-specific utility software.

L. Network Automation Engine (NAE)/ System Controllers

1. The Network Automation Engine (NAE)/ System Controllers or approved equal shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.
2. Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.
3. User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
 - a. The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
 - b. The NAE shall support up four (4) concurrent users.
 - c. The web based user shall have the capability to access all system data through one NAE.
 - d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.
 - e. Systems that require the user to address more than one NAE to access all system information are not acceptable.
 - f. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.
 - g. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
 - h. The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:
 - i. Configuration
 - ii. Commissioning
 - iii. Data Archiving
 - iv. Monitoring
 - v. Commanding

- vi. System Diagnostics
 - i. Systems that require workstation software or modified web browsers are not acceptable.
 - j. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
- 4. Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.
- 5. Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
- 6. Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.
- 7. The NAE shall include troubleshooting LED indicators to identify the following conditions:
 - a. Power - On/Off
 - b. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
 - c. Ethernet Connection Speed – 10 Mbps/100 Mbps
 - d. FC Bus – Normal Communications/No Field Communications
 - e. Peer Communication – Data Traffic Between NAE Devices
 - f. Run – NAE Running/NAE In Startup/NAE Shutting Down/Software Not Running
 - g. Bat Fault – Battery Defective, Data Protection Battery Not Installed
 - h. Fault – General Fault
 - i. Modem RX – NAE Modem Receiving Data
 - j. Modem TX – NAE Modem Transmitting Data
- 8. Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
 - a. Up to two (2) USB port
 - b. Up to two (2) URS-232 serial data communication port
 - c. Up to two (2) RS-485 port
 - d. One (1) Ethernet port
- 9. Diagnostics – The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
- 10. Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating

system software.

- a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
- b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

11. Certification – The NAE shall be listed by Underwriters Laboratories (UL).

12. Controller network – The NAE shall support the following communication protocols on the controller network:

- a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
 - i. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.
 - ii. The Conformance Statements shall be submitted 10 day prior to bidding.
 - iii. The NAE shall support a minimum of 100 control devices.
- b. The NAE shall support the Johnson Controls N2, Tridium FX-40, or Honeywell Webs or approved equal Field Bus.
 - i. The NAE shall support a minimum of 100 N2 control devices.
 - ii. The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.
 - iii. The Bus shall employ a master/slave protocol where the NAE is the master.
 - iv. The Bus shall employ a four (4) level priority system for polling frequency.
 - v. The Bus shall be optically isolated from the NAE.
 - vi. The Bus shall support the Metasys Integrator System.

2.2. WIRING

- A. The multi-conductor cable for field wiring of electronic analog sensors shall be minimum No. 22 AWG, 300 volt, thermoplastic with stranded copper wire and 100 percent shield coverage. The number of conductors in each sensor cable shall be as determined by the Contractor. 2/c #22 shielded cables shall be Belden Cat. #8451 3/c #20 shielded cables shall be Belden Cat. #9770 or approved equal.
- B. Conductors for digital sensors or contact control shall be the same as for the analog sensors, except the grounded shield is not required.
- C. Individual conductors shall be color coded and in addition shall be numbered in the field to identify the particular terminal to which attached. Field numbering shall be performed with Brady or approved equal markers wrapped around the wire near the terminal connection. All wires shall be terminated with pressure type connectors suitable for wire size, material and terminal connection.

- D. All exposed wiring or wiring concealed in partitions shall be installed in a designated conduit raceway. The conduit shall conform to Division 26 of the specification. Where wiring is installed in an air plenum the same shall be plenum rated cable.
- E. All junction boxes shall have covers painted safety green, and be rigid steel.
- F. All wiring between differential pressure transmitters and variable frequency drive pump controllers shall be shielded and grounded at the pump controller end. Directly route the variable frequency drive pump controller to the differential pressure transmitter(s).
- G. All wiring between air flow monitoring stations and variable frequency drive fan controllers shall be shielded and grounded at the fan controller end. Directly route the variable frequency drive fan controller to the air flow monitoring stations.
- H. All control wiring between VRV compressor units, branch selector boxes, and indoor VRV units shall be shielded and grounded per VRV manufacturer requirements.

2.3. CONTROLLERS

- A. Temperature, humidity, and CO2 sensor covers shall be stainless steel wire guard type with vandal proof screws. All room humidity, CO2, and temperature sensors shall be mounted 4'-0 inches above the finished floor, except in stairways, corridors and toilets, which shall be 7'-0 inches. Provide insulating bases where temperature sensors are located on exterior or unconditioned walls. Each temperature sensor shall have adjustable limit stops and adjustable sensitivity. User adjustment shall be 2 degrees F above and below set points or as determined by the Owner. Room temperature sensors shall include range of 55 degrees F to 85 degrees F set point adjustment. Temperature sensors shall include set-point adjusters, U.L. approved for mounting base in air plenums, and RJ-11 jack for communications. Room temperature sensors shall be fully adjustable and shall display set point and actual temperature.
- B. Space sensor wiring shall be installed concealed where possible. Should the Division 23 Contractor be unable to do so then surface metal raceway shall be utilized as specified in Division 26.
- C. Low Limit Thermostats: Freezestats shall have a minimum 20 foot (averaging sensing element) capillary tube sized to the basis of one linear foot of capillary tube for each square foot of coil surface. Thermostat sensitivity shall be adjustable. Freezestats shall stop supply and return fans and close the outside air damper if mixed air temperature drops below 35 degrees F and open hot water heating valves. Additional requirements are indicated in Sequence of Operation.
- D. Room temperature sensors shall be accessible to ADA occupants.

2.4. DAMPERS

- A. Control Dampers
 - 1. The temperature control contractor shall provide all automatic control dampers of the types indicated on the plans and not specified to be integral with other equipment. Frames shall be not less than 16 gauge galvanized steel. Blades shall

not be over 6 inches wide airfoil shaped double skin construction of 14 gauge equivalent thickness. Bearings shall be stainless steel sleeves with 2 inch shafts. Blade edge seals shall be vinyl blade with flexible metal compressible jamb seals of the tight-seal spring type. Dampers and seals shall be suitable for temperature ranges of -40 to 250 degrees F.

2. All proportional control dampers shall be opposed blade type and all two-position dampers shall be parallel blade type.
3. Dampers shall be sized to meet flow requirements of the application. The sheet metal contractor shall furnish and install baffles to fit the damper to duct size. Baffles shall not exceed 6 inches.
4. Dampers shall be minimum leakage type to conserve energy and the temperature control manufacturer shall submit leakage and flow characteristic data for all control dampers with the temperature control submittal. Maximum leakage shall be 3 CFM/Sq. Ft. at static pressure of 1 inch W.C. for a damper width of 48 inches.
5. Ultra-low leakage dampers shall have blade edges shall to be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 2 percent at applied static pressure.
6. Low pressure rectangular control dampers shall be Type CD60 airfoil low leakage damper as manufactured by Ruskin or as approved equal of American Warming and Ventilating, Air Balance and Arrow.
7. Round control dampers shall be Type CERS25 with blade edge seals as manufactured by Ruskin or as approved equal.
8. Provide damper end switch for all control dampers where indicated. Damper end switch shall be independent of the damper actuator and shall provide "proof of open" prior to allowing fan to energize. Damper end switch shall be Model TS-475 Mechanical Damper Arm Switch (no-mercury) as manufactured by MDI, Inc. or approved equal. Install per manufacturer's recommendations on control damper. End switch shall have the following features:
 - a. Housing Material: Glass filled PBT (polybutylene terephthalate).
 - b. Bracket Material: Plated steel.
 - c. Operation: Steel ball actuated sub-miniature snap action switch.
 - d. Operating angle: 15 degrees. (Contact closes at 10 degrees above horizontal and contact opens at 5 degrees below horizontal).

B. Duct Smoke Detectors

1. Duct smoke detectors shall be provided by the Electrical Contractor and installed by the Mechanical Contractor. All wiring, interlocks, etc., to be provided by Electrical Contractor. Wiring from duct smoke detectors to fans shall be by ATC Contractor. Duct smoke detectors shall be tested by the Test and Balance Engineer as specified in Division 23 Section, Testing Adjusting & Balancing for HVAC and Plumbing.

C. Damper Operators

1. Electric damper actuators shall be properly sized to provide sufficient torque to position the damper throughout its operating range.
2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection.
3. Electric actuators requiring a 24 VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e.: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-20Ma etc.) without the need for any additional interface devices.
4. For all exterior damper operators provide NEMA 4X stainless steel corrosion resistant enclosure. Damper operator enclosure shall be model ZS-300 as manufactured by Belimo or approved equal.

2.5. HYDRONIC CONTROL VALVES (GEOTHERMAL ROOFTOP UNIT)

- A. All automatic control valves 2 inches and smaller shall be screwed type, and valves 2 ½ inches and larger shall be flanged. Valves shall be factory-rated to withstand the pressures encountered. Valves shall have stainless-steel stems and spring loaded Teflon packing with replaceable seats and discs. All control valves must be capable of withstanding the shut-off head of the pump, they are connected to without the valve seat lifting. Valves shall have stainless steel stems and spring loaded Teflon packing with replaceable seats and discs.
1. All modulating straight-through water valves shall be provided with equal-percentage contoured throttling plugs. All three-way valves shall be provided with linear throttling plugs such that the total flow through the valve shall remain constant regardless of the valve's position modulating. Valves shall be sized for a pressure drop equal to the coil they serve but not to exceed 5 psi. Valves shall have replaceable seats and discs.
 2. Where applicable, all two (2) position (i.e. "open"/ "closed") control valves may be furnished with hose kits at Contractor's option. Coordinate actuator and pressure drop requirements with hose kit supplier. Maximum allowable pressure drop for two (2) position control valves shall be 3 feet at scheduled flow rate. Control valves used for non-modulating applications (i.e. "open" / "closed") shall be full line size not reduced in size due to the lack of need for valve authority
 3. Optional accessories shall include a stem packing lubricator for factory or field assembly. Valve stem packing shall be low friction, tight sealing Teflon.
 4. Unitary valves shall be straight-through or three way type as specified in the sequence of operation with high-pressure connections suitable for copper pipe and rated for 250 psig. Stems shall be polished stainless-steel and packing shall be ethylene-propylene suitable for both chilled water and 250 degree hot water service. Straight-through valves shall have back-seating feature, to allow packing

to be replaced without draining system.

5. All valves shall use guided valve plugs for good seating and reliable operation. Valves ½ inch to 1 inch shall be ANSI Class 125 brass body with screwed ends. Valves 1-1/4 inches to 2 inches shall be ANSI Class 150 brass body with screwed ends. Valves 2-1/2 inches to 4 inches shall be Class 125 cast iron body with bronze trim and flanged ends. Valves 6 inches and larger shall be Class 125 steel body with bronze trim and flanged ends. Butterfly valves shall be DeZurick HIGH performance or Keystone Keylock, Lug style as specified in Division 23 Section, HVAC Piping, Fittings, and Valves.
6. All heating coil valves shall be normally open to the coil.

B. Control Valve Operators

1. Electric valve actuators shall be properly sized to provide sufficient torque to position valves throughout its operating range.
2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection. Spring return valves are required for all control valves where coils are exposed to outside air conditions.
3. Electric actuators requiring a 24VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-10Ma

2.6. PRESSURE INDEPENDENT HYDRONIC CONTROL VALVES (HEATING WATER VALVES)

- A.** All automatic control valves 2 inches and smaller shall be screwed type, and valves 2 ½ inches and larger shall be flanged. Valves shall be factory-rated to withstand the pressures encountered. Valves shall have stainless-steel stems and spring loaded Teflon packing with replaceable seats and discs. All control valves must be capable of withstanding the shut-off head of the pumps, they are connected to without the valve seat lifting. Valves shall have stainless steel stems and spring loaded Teflon packing with replaceable seats and discs.
1. All modulating straight-through water valves shall be provided with equal-percentage contoured throttling plugs and shall be pressure independent type. All three-way valves shall be provided with linear throttling plugs such that the total flow through the valve shall remain constant regardless of the valve's position modulating. Valves shall be sized for a pressure drop equal to the coil they serve but not to exceed 5 psi. Valves shall have replaceable seats and discs. Pressure independent control valves shall be as manufactured by Griswold, Delta P, Warren Controls, Danfos, Bray, or approved equal.
 2. Pressure Independent Actuated Ball Valves (PIC-V) for Flows up to 85 GPM

- a. The modulating control valves shall be pressure independent.
- b. Valves shall accurately control flow within +/-5% (including manufacturing tolerance) independent of system pressure fluctuation by maintaining a constant pressure differential across the control valve so that the valve only repositions on a change in load demand.
- c. The pressure independent modulating control valve shall include a Pressure Compensating Cartridge, Actuated Ball Valve, 2 PT's, Manual Air Vent, Union, and Manual Isolation Ball in a single valve housing.
- d. The valve shall have an accuracy of +/- 5% including manufacturing tolerances and pressure variations.
- e. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F.
- f. Valve shall include a venturi metering station so that the flow rate can be read by means of differential pressure. Venturi metering station shall not require any straight runs of piping before or after meter.
- g. Both the ATC and shutoff valve shall have stems that are field repairable with the valve in the line. The body design shall allow inspection or repair of the stem without disturbing piping connections or draining water. The repairable stem shall include two Teflon seals and one EPDM O-ring for protection against chemicals and modulating temperature.
- h. Valve shall have a union end connection with factory installed air vent to allow for venting of the coil or heat pump.
- i. The control valve shall accurately control the flow from 0 to 100% full rated flow.
- j. The ATC portion of the valve shall use the full 90 degrees of the stroke for control. Stroke limiting of the valve shall not be acceptable.
- k. A flow tag shall be furnished with each valve.
- l. A universal mounting plate shall allow installation of actuators meeting the system electrical requirements and valve torque requirements as provided by Honeywell, Invensys, Johnson Controls, KMC, Schneider, Neptonic, or Siemens.
- m. The actuator and plate can be rotated after mounting.
- n. The actuator mounting assembly shall accommodate no less than 1 ½" of insulation.
- o. Pressure Compensating Cartridge (PCC)
 - i. PCC shall automatically compensate for pressure changes in valve and shall maintain a constant pressure drop across the flow limiting actuated ball.
 - ii. The operating pressure range shall be available with the minimum range requiring 3 PSID to actuate the cartridge and the maximum 8 psid to actuate the cartridge
 - iii. Valve internal control mechanism includes a diaphragm and full travel linear coil spring.
 - iv. Valves shall include an accessible/ replaceable cartridge.
 - v. Dual pressure/temperature test valves for verifying the pressure differential across the cartridge and flow limiting ball shall be standard.
- p. Actuated Ball Valve
 - i. Valve ball shall consist of chemically plated nickel brass or stainless steel.
 - ii. Actuator stem shall be removable/ replaceable without removing

- valve from line.
- iii. Manufacturer shall be able to provide ball insert to limit flow to maximum flow rate with $\pm 5\%$ accuracy. Insert shall be constructed of a Glass-Filled Polymer. The insert shall be press fit to the inside of the ball. Clipping the insert onto the exiting side of the ball shall not be acceptable.
- iv. Each maximum flow rate selected shall use a different characterizing disc so that stroke limiting is not required.
- v. Valve shall have a minimum rangeability as follows: $\frac{1}{2}$ "-40:1, $\frac{3}{4}$ "-160:1, 1" to 3"-400:1
- vi. Valve shall have EPDM O-rings behind Reinforced Teflon (PTFE) ball seals.
- vii. The valve shall have a minimum close-off pressure differential rating of 100 psi with 35 in-lbs of torque for $\frac{1}{2}$ " to 2" sizes.
- viii. Actuator shall provide minimum torque required for full valve shutoff position.
- q. Isolation Ball Valve
 - i. Valve shall include a 600 WOG manual isolation ball valve.
 - ii. Stem shall be removable/replaceable with the valve in the line.
- r. The control valve actuator will be furnished by the controls contractor under Section 230900.
- s. Pressure independent valves shall come as one complete assembly from Griswold Controls or approved equal and shall include a supply side combination shutoff/ strainer valve.

3. MVP Pressure Independent Control Valves for Flows above 85 GPM.

- a. Pressure Independent Flow Control Valve 2.5" and Larger
 - i. The modulating control valves shall be pressure independent.
 - ii. Valve shall accurately control flow within $\pm 5\%$ (including manufacturing tolerance) independent of system pressure fluctuation by maintaining a constant pressure differential across the control valve so that the valve only repositions on a change in load demand.
 - iii. Contactor shall install pressure independent flow control valves where indicated in drawings.
 - iv. Valve shall be electronic, pressure independent, modulating 2-way control device.
 - v. Balancing valves shall not be required where pressure-independent valves are installed.
 - vi. Install flow measuring station and shut-off valve on return pipe to measure flow rate in gallons per minute.
- b. Valve Actuator
 - i. Valve actuator housing shall be rated to IP44 insulation.
 - ii. Actuator shall be driven by a 24Vdc motor, and shall accept 2-10 Vdc, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.
 - iii. Actuator shall be capable of providing 4-20mA or 2-10 Vdc feedback signal to the control system so that the gpm can be

- determined.
- iv. External LED readout of current valve position and maximum valve position setting shall be standard.
- v. Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size by changing the settings electronically on the actuator.
- vi. Optional fail safe system to power valve to either open or closed position from any position in case of power failure shall be provided per the sequence of operations and the automatic temperature control diagrams.
- c. Valve Housing
 - i. 2.5"–6": Housing shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 580 psi static pressure and 248°C.
- d. Pressure Regulation Unit
 - i. Pressure regulation unit shall consist of 304 Stainless Steel and hydrogenated acrylonitrile butadiene rubber (1/2"–1-1/2") or 316 Stainless Steel and EPDM (2"–6").
 - ii. Flow regulation unit shall be accessible for maintenance without disturbing the piping.
 - iii. Valve shall have a maximum of 8.6 psid to actuate the pressure regulating cartridge.
 - iv. Dual pressure/temperature test valves for verifying accuracy of flow performance shall be available for all valve sizes.
- 4. Coordinate actuator and pressure drop requirements. Maximum allowable pressure drop for two (2) position modulating control valves shall be 12 feet at scheduled flow rate.
- 5. Optional accessories shall include a stem packing lubricator for factory or field assembly. Valve stem packing shall be low friction, tight sealing Teflon.
- 6. Unitary valves shall be straight-through or three way type as specified in the sequence of operation with high-pressure connections suitable for copper pipe and rated for 250 psig. Stems shall be polished stainless-steel and packing shall be ethylene-propylene suitable for both chilled water and 250 degree hot water service. Straight-through valves shall have back-seating feature, to allow packing to be replaced without draining system.
- 7. All valves shall use guided valve plugs for good seating and reliable operation. Valves ½ inch to 1 inch shall be ANSI Class 125 brass body with screwed ends. Valves 1-1/4 inches to 2 inches shall be ANSI Class 150 brass body with screwed ends. Valves 2-1/2 inches to 4 inches shall be Class 125 cast iron body with bronze trim and flanged ends. Valves 6 inches and larger shall be Class 125 steel body with bronze trim and flanged ends. Butterfly valves shall be DeZurick HIGH performance or Keystone Keylock, Lug style as specified in Division 23 Section, HVAC Piping, Fittings, and Valves.
- 8. All heating coil valves shall be normally open to the coil.

B. Control Valve Operators

1. Electric valve actuators shall be properly sized to provide sufficient torque to position valves throughout its operating range.
2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection. Spring return valves are required for all control valves where coils are exposed to outside air conditions.
3. Electric actuators requiring a 24VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e.: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-10Ma etc.) without the need for any additional interface devices.

2.7. CONTROL PANELS

- A. Furnish and install local panels for ATC devices. Control panels shall be fully enclosed cabinets, all steel construction and shall meet the requirements of NEMA 1 enclosures. Cabinet shall have piano hinged door with a locking latch. All cabinet locks shall use common key. Provide means of storing control system instructions and drawings inside cabinet for future reference. Panel shall be wall mounted or free standing and located where directed by the Contract Drawings or Engineer.
 1. Each panel shall have all internal devices factory wired to a numbered terminal strip. Controllers and associated devices shall be mounted within the panel, accessible through a hinged door.
 2. All ATC panels shall be provided with integral disconnect, wiring, and control transformers.
 3. Any ATC control panel that is serving equipment on the emergency generator must be powered by an emergency generator fed circuit/electrical panel. Refer to electrical contract documents for all emergency powered equipment.

2.8. MISCELLANEOUS ELECTRICAL DEVICES

- A. Electric Actuators. All automatically controlled devices, unless specified otherwise elsewhere, shall be provided with electric actuators which shall be sized to operate their appropriate loads with sufficient reserve power to provide smooth modulating action or two-position action and tight close off as specified.

2.9. UNINTERRUPTIBLE POWER SUPPLY

- A. Furnish, size and install uninterruptible power supplies (UPS's) at all ATC panels.
- B. Provide all interlock and power wiring from U.P.S. to control panels as required such that all components are powered via the UPS. For hard-wired equipment furnished with pigtails/wire leads, e.g. control power transformers, splice pigtails/wire leads in junction box to a flexible cord with NEMA 5-15P Plug, which shall be plugged into the UPS.

- C. UPS's shall be sized for the ATC panel load and shall provide at least 10 minutes of full load power in the event of a power outage.
- D. UPS shall be furnished with plug and cord and shall be powered from power receptacle(s) in ATC panels.

2.10. DESKTOP WORKSTATIONS

- A. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.
- B. Performance Requirements:
 - 1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 - 2. Energy Star compliant.
- C. Personal Computer:
 - 1. Minimum Processor Speed: 3 gigahertz (GHz).
 - 2. RAM:
 - a. Capacity: 8GB.
 - b. Speed and Type: 1333 MHz, SDRAM.
 - 3. Hard Drive:
 - a. Media: Solid state.
 - b. Number of Hard Drives: One.
 - c. Capacity: 250GB.
 - 4. Optical Read and Write Drive:
 - a. Include with at least 2 MB of data buffer.
 - b. Type: SCSI CD-ROM Drive with Read/Write Capability.
 - c. Average access time of 150 ms or less.
 - 5. At least four expansion slots.
 - 6. Video Card:
 - a. Resolution: 1920 by 1200 pixels.
 - b. RAM: 4 GB.
 - c. Controller Speed: 4GHz.
 - 7. Sound Card:
 - a. At least 128 voice wavetable synthesis.
 - b. Capable of delivering three-dimensional sound effects.
 - c. High-resolution 16-bit stereo digital audio recording and playback with

user-selectable sample rates up to 48,000 Hz.

8. Network Interface Card: Include card with connection, as applicable.
 - a. 10-100-1000 base TX Ethernet with RJ45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
- D. Wireless Ethernet, 802.11 a/b/g/n.
 1. Optical Modem: Full duplex link for connection to optical fiber cable provided.
 2. I/O Ports:
 - a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
 - b. One serial port.
 - c. One parallel port.
 - d. Two PS/2 ports.
 - e. One RJ-45.
 - f. One stereo line-in and headphone/line-out on back panel.
 - g. One microphone and headphone connector on front panel.
 - h. One IEEE 1394 on front and back panel with PCI-e card.
 - i. One ESATA port on back panel.
 3. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.
- E. Keyboard:
 1. 101 enhanced keyboard.
 2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
 3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.
- F. Pointing Device:
 1. Either a two- or three-button mouse.
 2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.
- G. Flat Panel Display Monitor:
 1. Display:
 - a. Color display with 21 inches diagonal viewable area.
 - b. Digital input signal.
 - c. Aspect Ratio: 16 to 9.
 - d. Antiglare display.

- e. Tilt adjustable base.
- f. Energy Star compliant.
- g. Resolution: 1920 by 1200 pixels at 60 Hz.
- h. Number of Displays: One.

H. Speakers:

- 1. Two, with individual controls for volume, bass and treble.
- 2. Signal to Noise Ratio: At least 65 dB.
- 3. Power: At least 4 W per speaker/channel.
- 4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

2.11. CENTRAL CONTROL AND MONITORING SYSTEM (CCMS) (HARDWARE DESCRIPTION)

A. General

- 1. The Facilities Management Control System (FMCS) shall be comprised of a network of various independent, Stand-alone Digital Controllers (SDC'S), Mechanical System Digital Controllers (MSDC's), Air Handler Digital Controllers (AHDC's), Unitary Digital Controllers (UDC's),; together with Centralized Control Stations (CCS), and Centralized Host Stations (CHS) as specified, to provide centralized access and facility wide control functions. The SDC's, MSDC's, AHDC's, UDC's shall be interconnected in a communicating network to provide facility wide access and sharing of information. A Gateway Digital Controller (GDC's) shall be provided to allow interface with third party microprocessor based control systems that are specified for integration within specification. A Local Area Network (LAN) shall be provided to interconnect SDC's for high-speed data transmission.

2. Specification Nomenclature

- | | | |
|----|------|--------------------------------------|
| a. | FMCS | Facility Management Control System |
| b. | SDC | Stand-alone Digital Controller |
| c. | MSDC | Mechanical System Digital Controller |
| d. | AHDC | Air Handler Digital Controller |
| e. | UDC | Unitary Digital Controller |
| f. | HHOT | Hand Held Operator Terminal |
| g. | GDC | Gateway Digital Controller |
| h. | GP | Graphical Programmer |
| i. | CHS | Central Host Station |
| j. | CCS | Central Control Station |
| k. | RPTR | Communications Repeater |

B. Centralized Host Stations (CHS)

1. The FMCS shall include Centralized Host Stations. CHS's shall, in conjunction with the full compliment of Digital Controllers, provide the performance requirements within this specification. Each CHS shall include all hardware and software components to serve as a centralized facility operator station, providing color graphics, facility wide access, operator initiation of global control strategies, and centralized documentation.

The CHS shall be capable of simultaneously interfacing with the following:

- a. -mouse pointing device
- b. -two parallel printers
- c. -high resolution VGA color graphics monitor
- d. -seven auto answer/auto dial modems
- e. -color inkjet printer
- f. -two serial printers
- g. -three FMCS LAN interface
- h. -Alarm Graphic and Report FAX dial out service interface
- i. -Mass storage tape system

As a minimum, the temperature control contractor shall provide the types and quantities of CHS, CCS, SDC, MSDC, AHDC, GDC, and UDC as required.

2. Computer

- a. The existing FMS computer located in the Maintenance Office shall be utilized with the new CCMS System if compatible with the same. If the selected ATC contractor cannot tie into the existing computer, then a new stand-alone computer shall be furnished.
- b. The existing FMS computer located in the School Districts Central Maintenance Office shall be utilized with the new CCMS System. Provide modem terminal, and wiring as required to interface this school's CCMS system with FMS computer. I/P data drop shall be provided adjacent to the network panels.
- c. Coordinate IP address with Owners' I.T. Department for network connection. The CCMS must be fully networkable.
- d. Provide fiber optic cable as required.

3. Operator Workstation: One PC-based microcomputer with minimum configuration as follows:

- a. Uninterruptible Power Supply: 2 kVa.
- b. Operating System: Microsoft Windows – Latest Version.
 - i. ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
 - ii. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
- c. Printer: Color, ink-jet type as follows:
 - i. Print Head: 4800 x 1200 dpi optimized color resolution.

- ii. Paper Handling: Minimum of 100 sheets.
- iii. Print Speed: Minimum of 17 ppm in black and 12 ppm in color.

C. Centralized Control Stations (CCS)

- 1. The FMCS shall include Centralized Control Stations, as required. CCS's shall, in conjunction with the network of SDC's and additional CCS components as required, provide the performance requirements within this section of the specification. Each CCS shall include all hardware and software components to serve as a centralized facility operator station, providing facility wide access, for review and modification of global control strategies, real time system monitoring, controller database editing or creation, and centralized documentation.

D. Local Area Networks

- 1. The LAN shall utilize packetized transmissions, CRC 16 error checking, and distributed error recovery. Single or multiple SDC failures shall not cause loss of communication between other LAN-connected SDC's.
- 2. LAN connected SDC's shall be provided with a communications watchdog to assure that an individual SDC cannot permanently occupy the LAN. If an SDC is determined to be monopolizing communications, it shall be automatically shut down and an exception reported to annunciate this fact.
- 3. The LAN shall employ a token passing, peer-to-peer convention, same as or similar to the industry standard format IEEE 802.4. The content of messages shall be the manufacturer's standard. The Local Area Network components shall be manufacturer's standard or available from third party vendors which utilize the same chip implementation as used by the manufacturer.
- 4. Industry standard ANSI, RS-485 Network Communication System, Lon, or Bacnet, or Equivalent shall be utilized.
- 5. Trunk Wiring Practices - General
 - a. The distributed communication network system shall consist of a multi-drop RS-485 bus architecture connecting SDC's, MSDC's, AHDC's, GDC's, and UDC's The trunk shall consist of:
 - i. A twisted pair of wires (24 awg) completely encased in continuous metallic conduit.
 - ii. A twisted shielded pair of wires (24awg) with the shield grounded in accordance with the manufacturer's wiring practices.
 - iii. Or a dual channel, 62.5 micron fiber cabling system with ST type connectors.There shall be no power wiring, in excess of 30 VAC rms voltage, run in conduit with communications trunk wiring. In cases where power or signal wiring is run in conduit with trunk wiring, all communications trunk wiring and power wiring shall be run using separate twisted shielded pairs (24awg) with the shields grounded in accordance with the manufacturer's wiring practices.
 - b. Communication Transient Protection

- i. The manufacturer's catalog data sheet shall provide evidence that all FMCS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.
 - ii. In addition, at each building entry and exit point, the wire communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General semiconductor, Model #422E device. Transient surge protection is not necessary if the communication trunk, external to the building, is fiber optic in nature.
 - iii. The communications circuitry and input/output circuitry, of the SDC's, MSDC's, and AHDC's, shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer's catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the FMCS controller. Protection shall be provided for the individual communications and input/output terminations for each FMCS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.
- c. RS-485 Trunk Distance and Topology
The manufacturer's RS-485 trunk shall provide operation over end to end linear distances of 4000 feet for wire connections and 6,500 feet for fiber optic connections, without repeaters, at communication data rates of up to 64 kbps. The trunk may be extended up to 20,000 feet through the use of wire repeaters or 80,000 feet through the use of fiber optic repeaters. At data rates of up to 19.2 kbps, the trunk distance shall be extendible to distances of up to 20,000 feet using RS-485 communication wire or fiber optic repeaters. A repeater shall be used each 4,000 feet of linear distance for wire or every 6,500 feet for fiber optics. Repeating devices shall contain separate LED indication for each communication interface trunk to indicate proper operation of the repeater as well as the communications trunks.
Contractors shall provide devices which are of FMCS control system manufacturer's design.
- d. It shall be possible for the trunk to be "T" eed or "starred", at any location using a repeater, to facilitate the installation. Systems which do not provide this capability shall provide a trunk riser diagram showing end to end distances and locations of system topology necessary to meet the trunk diagram shown on the plans.
 - e. Fiber Optic Communication Trunk

The temperature control contractor shall provide a dual channel fiber optic data link, as required, to minimize the effects of transient surges caused by lightning or external EMI generating equipment. The data link shall be comprised of a single duplex cable containing two fibers (transmit and receive), of 62.5 micron construction, to accommodate data rates of up to 64 kbps.

The fiber optic trunk shall be connected to SDC devices using manufacturer's standard RS-485 to fiber optic data link modem. Repeating devices shall contain separate LED indication for each communication interface and the fiber modem, to indicate proper operation of all aspects of the device. Fiber modem devices shall be tested and conform with transient surge withstand tests for electrical devices, ANSI C62.41 IEEE-587 Categories A and B. Manufacturer's data sheet shall provide evidence of compliance with this requirement. Manufacturer's products which do not meet this minimum performance requirement shall not be acceptable. Systems which require a special gateway controller to accommodate the fiber optic trunks, shall provide such a controller per point where the fiber optic cable enters and leaves the building. Gateway controllers shall not inhibit transfer of point data values between SDC controllers throughout the LAN. Such inhibitive systems shall not be acceptable.

In lieu of the above two options, the contractor may provide a fiber optic link to each SDC controller within the LAN. All controllers shall have access to the fiber optic link for LAN.

Fiber optic cable shall be fully tested and terminated by the temperature control contractor.

E. Standalone Digital Controllers (SDC)

1. General

Standalone Digital Controllers (SDC) shall be 16 bit microcomputer based, utilizing a multi-tasking, multi-user operating system.

The SDC controllers shall permit the simultaneous operation of all control, communication facilities management and operator interface software, as programmed by the Contractor or User. Modification of the on-board SDC controller database shall be performed on-line using the built-in or HHOT interface. Systems which require the SDC to be removed from service while DDC control sequences are modified shall not be acceptable.

SDC controllers shall utilize true floating point arithmetic capabilities. To accommodate totalization of large totalized values, SDC's with reporting capability shall support the calculation, accumulation and display of values within the range of +/-10 to the 10th power.

2. Database and Memory Back-up

All programming defining the functions to be performed by the SDC, including but not limited to application programs and point database within each SDC, shall be protected from loss due to power failure for a minimum of six months. Systems providing non-volatile memory for these functions are preferred. Systems not

providing non-volatile memory shall provide a system rechargeable battery backup system sufficient to provide protection for the specified 6 month period. Systems not in compliance shall provide for uninterrupted power to each SDC.

3. Service Ports

SDC controllers shall be equipped with a minimum of one operator service port for the connection of a HHOT. The service port shall be either a built-in RS-232 data terminal port or an RJ-11 type jack which connects to the manufacturer's standard HHOT.

Connection of a service device, to a service port, shall not cause the SDC controller to lose communications with its peers or other networked device controllers.

The service port shall allow utilization of the same HHOT from any location. The same HHOT shall be utilized for any SDC, MSDC, AHDC, and UDC, Systems which utilize more than one variety of HHOT shall not be acceptable.

4. Display and Readout Capability

The SDC controller shall provide manufacturer's standard display and readout capability.

5. Manual/Auto Control and Notification

The SDC controller shall provide commanded override capability from the HHOT or the built-in operator interface. Such overrides shall be annunciated to the CHS's. Such overrides shall be valid as long as power is applied to the controller.

Manual service overrides, such as Hand/Off/Auto switches, shall be provided as indicated on the drawings. Such overrides shall be located at the controlled device location and conform with OSHA Manual lockout regulations, as appropriate, for safety reasons. SDC indication of such manual override actions shall be provided as feedback status indication points shown on the drawings, in conjunction with the application programs within the SDC. Systems which provide built-in H/O/A switching devices with integral feedback shall provide external manual service overrides, as indicated, to comply with OSHA manual lockout regulations. H/O/A switches remotely located at the SDC controller are not acceptable.

6. Adjustments

Every control panel shall provide adjustments for the functions specified. In general, adjustments shall be provided for all set points used by controllers within each control panel. In addition, adjustments shall be provided for throttling ranges, mixed air damper minimum positions, or other items as specified. Adjustments shall be integral to each individual SDC. The built-in operator interfaces shall allow the easy execution of the adjustment through named identifiers within the SDC. From a single SDC user interface, any other SDC shall be accessible and full adjustment capabilities shall be provided.

7. Sensing and Control Outputs Requirements

a. Sensing

i. All sensing inputs shall be provided via industry standard signals. Temperatures, humidities, differential pressure signals, and other signal inputs shall be one of the following types:

1. 0-20 mA
2. 4-20 mA
3. 0-5 VDC
4. 0-12 VDC

ii. 1000 ohm platinum (at $0.01^{\circ}\text{C}/^{\circ}\text{C}$, 2.62 ohms/ $^{\circ}\text{C}$)

iii. 1000 ohm Balco (2.2 ohms/ $^{\circ}\text{C}$)

iv. 10 k ohm Thermistor (at 25°C , $10^{\circ}\text{C}/^{\circ}\text{C}$)

Custom, definable input signals (accept sensor inputs from RTD devices, other than those of the manufacturer).

All signal inputs shall be compatible with the controllers used, and with the requirements for readout of variables in true scaled engineering units as specified.

b. Control Outputs

i. On/Off Outputs

Control panel shall internally provide test points for the circuit driving the equipment contactor, for the purpose of troubleshooting the 120 VAC or 240 VAC circuit to the contactor. All such relays or digital output modules shall provide a pilot light or LED display of the same status. On/Off output modules shall be of the modular construction that can be easily and quickly replaced, on an individual basis, if the module were to be damaged.

ii. Modulating Outputs

Modulating outputs shall be industry standard 0-5 VDC, or 0-12 VDC with definable output spans, to adapt to industry available control products. Milliamp outputs of 0-20 mA or 4-20 mA are also acceptable. Drive open/Drive closed type modulating outputs are acceptable provided that they also comply with the following requirements.

All modulating outputs shall provide within the control panel, a meter gauge, or display indication via on board display or HHOT, the commanded position signal for the actuating device. This meter, gauge, or display must provide either a 0-100 percent position indication, or read out directly in the engineering unit of the signal being used. Drive open/Drive closed type controllers shall include sufficient components and control algorithms to comply with this requirement. In the case of Drive open/closed technology, position feedback shall be provided to insure positive indication that the control device is at the commanded position.

F. Mechanical System Digital Controllers (MSDC's)

1. General

a. Controls shall be microprocessor based, Mechanical System Direct Digital Controllers (MSDC's). MSDC's shall be provided for air handling units, central pump systems and other applications as required. MSDC's shall

be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the MSDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates sensor signals. All input/output signal conversion shall be performed through a minimum of a 12 Bit A to D converter. All input/output points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input/output points must be available as universally definable at the owner discretion. If input/output points are not fully universal in nature, unused points must be equal in quantity between Analog Input, Digital Input, Analog Output, Digital Output.

Contractor shall provide a minimum of one MSDC controller per mechanical system, as shown on the drawings.

The BAS contractor shall provide and field install all MSDC's specified under this section. Mechanical Equipment manufacturers desiring to provide MSDC type controls as factory mounted equipment, shall provide a separate bid for their product less all controls, BAS/Temperature Control Contractor.

- b. All input/output signals shall be directly hardwired to the MSDC. Trouble shooting of input/output signals shall be easily executed with a volt-ohm-milli-amp meter (VOMA). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be used.
- c. MSDC shall be in continuous direct communication with the network which forms the facility-wide Building Automation System (BAS). The MSDC's shall communicate with the SDC at a baud rate of not less than 19,200 baud.

2. Non-Volatile Memory

- a. All control sequences programmed into the MSDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained. Power failures shall not cause the MSDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The MSDC shall allow for the creation of unique application control strategies. Systems that allow selection of sequences from the library or table are not acceptable.
- b. All control sequences shall be fully field programmable at the MSDC controller, allowing for the creation or editing of an application sequence of operations.
- c. Each MSDC shall be provided with manufacturer's standard built-in Operator Interface.
- d. The MSDC shall allow for internal processing and reporting of user defined Time of Day Schedules, Alarms, Trend Reports, Run Time Totalization, Energy Utilization Reports, Application Program Documentation and interface with a peripheral device such as an autodial/autoanswer modem, a VT-100 Display Terminal, or a serial printer.
 - i. Systems not providing the above functionality at the MSDC are

- not acceptable and shall utilize an SDC in place of the MSDC.
- e. The MSDC shall provide LED indication of transmit/receive communications performance as well as for the proper/improper operation of the controller itself.
 - f. The MSDC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days without loss of setting. The battery for the time clock shall be field replaceable by the customer. Integral daily, weekly, holiday and special event scheduling shall be provided, such that all schedules can be custom tailored to the facility. Predefined schedules, with set quantities of on/off cycles are not acceptable.

3. Controller Location

- a. To simplify controls, mechanical service and troubleshooting, the MSDC shall be mounted directly in or on the control compartment of the mechanical system. The MSDC shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The MSDC shall be constructed in a modular orientation such that service of the failed components can be performed quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of three. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. The MSDC shall allow for the creation of, unique, application control strategies. Systems that allow selection of sequences from a library or table are not acceptable. This shall allow all controls maintenance and troubleshooting to be made while at the unit location. MSDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.
- b. For compatibility to the environment of the mechanical systems, MSDC shall have wide ambient ratings. MSDC shall be rated for service from - 40 Deg F (Degrees Fahrenheit) to 140 Deg F.
- c. Contractor shall submit description of location for the MSDC's on all mechanical equipment.

G. Air Handler, Energy Recovery Unit, Rooftop Geothermal Heat Pump Digital Controller (AHDC)

1. General

- a. Controls shall be microprocessor based, Air Handler Digital Controllers (AHDC's). AHDC's shall be provided for air handling units, energy recovery ventilators, and other applications as required. AHDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the AHDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter. All input points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input points must be available as universally definable at the discretion of the owner. If the input points are

not fully universal in nature, unused points must be equal in quantity between Analog Inputs and Digital Inputs.

Contractor shall provide a minimum of one AHDC controller per air handling system as shown on the drawings.

The BAS contractor shall provide and field install all AHDC's specified under this section. Mechanical equipment manufacturers desiring to provide AHDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

- b. All input/output signals shall be directly hardwired to the AHDC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.
- c. AHDC's shall be in continuous direct communication with the network which forms the facility wide Building Automation System. The AHDC's shall communicate with the SDC at a baud rate of not less than 19,200 baud.

2. Non-Volatile Memory

- a. All control sequences programmed into the AHDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the AHDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The AHDC shall allow for the creation of unique application control sequences. Systems that only allow selection of sequences from a library or table, are not acceptable.
- b. All control sequences shall be fully programmable at the AHDC, allowing for the creation and editing of an application control sequence, while at the unit.
- c. The AHDC shall be provided with an interface port for the HHOT. The interface port shall allow the HHOT to have full functionality as described. From the interface port, the HHOT shall be able to directly access any AHDC, UDC or VAVDC in the network.
- d. The AHDC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples, per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken. The samples shall be protected against loss due to power interruptions through a battery or capacitor backup method for a minimum of 30 days. Systems unable to provide the above capability shall provide for the individual Input/Output point trending at the SDC. Specifics as to how each AHDC point will be trended, at the SDC, shall be provided in the submittal documents. Included in the explanation shall be the sample

intervals, the memory allocation in the SDC and the number of AHDC's per SDC that can be expected.

- e. The AHDC shall provide LED indication of transmit/receive communications performance, as well as for the proper/improper operation of the controller itself.
- f. The AHDC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the AHDC, without loss of setting. The battery for the time clock shall be replaceable by the customer. The AHDC shall be provided with integral time schedules; as a minimum, two seven day schedules with eight on/off periods per day shall be provided. Holiday override of weekly schedules shall be provided for pre-scheduling of holidays, for the year in advance.

3. Controller Location

- a. To simplify controls and mechanical service troubleshooting, the AHDC shall be mounted directly in or on the controls compartment of the air handling system. The AHDC shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The AHDC shall be constructed in a modular orientation such that service of the failed components can be done quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of two. All logic, control system, power supply and input/output circuitry shall be contained on a single plug-in circuit board. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. This shall allow all controls maintenance and troubleshooting to be made while at the air handling unit. The AHDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.
- b. For compatibility to the environment of the air handling unit, AHDC's shall have wide ambient ratings. AHDC's shall be rated for service from -40 Deg F (Degrees Fahrenheit) to 140 Deg F.
- c. Contractor shall submit description of location of AHDC's on all mechanical and air handling equipment.

H. Unitary Digital Controller (UDC)

1. General

- a. Controls shall be microprocessor based Unitary Digital Controllers (UDC's). UDC's shall be provided for equipment as necessary. UDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the UDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter.

Contractor shall provide a minimum of one UDC controller per unitary system as required.

The BAS contractor shall provide and install all UDC's specified under

this section. Mechanical equipment manufacturers desiring to provide UDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

- b. All input/output signals shall be directly hardwired to the UDC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm-milli-amp meter (VOMA). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.
- c. UDC's shall be in continuous, direct communication with the network which forms the facility wide building automation system. The UDC's shall communicate with the SDC at a baud rate of not less than 9,600 baud.

2. Non-Volatile Memory

- a. All control sequences programmed into the UDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the UDC memory to be lost, nor shall there be any need for batteries to be recharge or replaced to maintain the integrity of the controller database. The UDC shall allow for the creation of unique application control sequences. Systems that allow only selection of sequences from a library or table are not acceptable.
- b. All control sequences shall be fully configurable at the AHDC, allowing for the creation and change of a sequence while at the unit.
- c. The UDC shall be provided with the ability to interface with the HHOT. The interface port shall be provided at the wall sensor or within the unitary equipment, as specified on the plans. The interface port shall allow the HHOT to have full functionality as described hereinbefore of this specification. From the interface port, the HHOT shall be able to directly access any AHDC, or UDC, in the network.
- d. The UDC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken. Systems unable to provide the above capability shall provide for the individual input/output point trending at the SDC. Specifics as to how each UDC point will be trended, at the SDC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the SDC and the number of UDC's per SDC that can be expected.
- e. The UDC shall provide LED indication of transmit/receive communication performance, as well as for the proper/improper operation of the controller itself.

3. Controller Location

- a. To simplify controls and mechanical service troubleshooting, the UDC shall be mounted directly in the controls compartment of the unitary system. The UDC shall be provided with a sheet metal or polymeric enclosure that is constructed of material allowing for the direct mounting within the primary air stream, as defined by UL-465. The direct mounting shall allow all controls maintenance and troubleshooting to be made while at the unitary equipment. The UDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.
- b. For compatibility to the environment of the unitary equipment, UDC's shall have wide ambient ratings. UDC's shall be rated for service from 32 Deg F (Degrees Fahrenheit) to 140 Deg F.
- c. Contractor shall submit description of location of UDC's on all mechanical and unitary equipment.

I. Gateway Digital Controller (GDC)

1. General

- a. Controls shall be microprocessor based, Gateway Digital Controllers (GDC's). GDC's shall be provided for the purpose of integrating microprocessor based, communicating, direct digital control systems from vendors other than the primary, selected controls manufacturer. GDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the GDC. All communications interface control programs shall be resident within the GDC.
The BAS contractor shall provide and field install all GDC's specified under this section. Any interface requirement beyond a two wire communications wire link, shall be provided by the equipment manufacturer supplying the non-primary or third party microprocessor based, communicating, direct digital controllers.
- b. All GDC's shall exist at the LAN level with the SDC's. The GDC's shall possess all capabilities described under the SDC section while additionally providing the interface to the third party systems described above. The GDC's shall communicate with the third party controllers at the highest possible baud rate offered by the third party system. As a minimum, 9,600 baud communications shall be utilized.
- c. All control sequences programmed into the GDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the GDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The GDC shall allow the standard database information from the third party system to be integrated in standard FMCS data formats, allowing for the creation of unique application control sequences. Systems that only allow selection of data and sequences from a library or table, are not acceptable.
- d. Each GDC shall be provided with manufacturer's standard built-in operator interface.
The GDC shall provide Alarming, point trending and Energy report generation capabilities. Alarming points shall be uniquely definable, with multiple alarms assignable to a single point. Such alarm shall be provided

with a unique 80 character message. Systems utilizing an alarm message library, shall describe the size of the library and verify how all alarming within the GDC will be guaranteed unique 80 character messages.

The quantities of trended point values shall be limited only by total controller memory space. If necessary, a GDC may be dedicated fully to a trending task, allowing all controller memory to be available for the trend storage. Each unique trend report shall contain a minimum of 4 different points and a minimum of 128 samples per point. Trending frequency for each report shall be operator definable from a sample once a second to a sample once every 24 hours. Trend reports shall be internally formatted by the GDC and shall be reportable directly to a serial printer, a VT-100 display terminal, a CCS, CHS or any other device capable of receiving a formatted ASCII data file.

- e. The energy reports shall not be limited in quantities only by available memory within the GDC. Each Energy Report shall be fully formatted and reportable to a serial printer, a VT-100 display terminal, a CCS, a CHS or any other device capable of receiving a formatted ASCII data file. As a minimum, each Energy Report shall provide a daily report and a monthly report with summary information such as outside air temperature, outside air humidity, total energy consumed and degree day calculations.
- f. The GDC shall be provided with a battery backed clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the GDC, without loss of setting. The battery for the time clock shall be field replaceable by the customer.

2.12. HEAT PUMP CONTROLLER

- A. All heat pump controls shall be provided by the ATC subcontractor. Heat pump controls furnished by the equipment manufacturer and integrated into the building automatic system are not acceptable. The use of unitary controllers for heat pumps is not acceptable. Heat pump controllers shall be fully programmable with sufficient memory and spare point capacity to accommodate expansion in the future.
 - 1. Heat pump controllers for the listed manufacturers subject to compliance with requirements shall be as follows:
 - 2. Johnson Control – DX9100.
 - 3. Trane

2.13. SYSTEM SOFTWARE DESCRIPTION

- A. General
 - 1. Contractor shall provide all software for a complete and operational system as described herein. Software shall include manufacturer's standard multi-tasking, multi-user operating system for operator consoles and controllers, network communication software for dial-up and hard trunk applications, operator man-machine interface software, control application software and all other software

necessary to provide the functions specified herein.

2. System software shall be as manufactured by Johnson Controls or Trane.

2.14. EXCEPTION REPORTING SEQUENCES

A. Alarm/COS Reports

1. For those digital points indicated on the drawings, the Contractor shall provide a unique change-of-state alarm message of up to 70 characters. The message shall report to all devices assigned to the alarm class.
2. For those points indicated on the drawings which are designated as interrupt priority, the Contractor shall provide an interrupting process display at the CHS location which displays the current conditions for the operator.

In addition, the CHS computer shall automatically send a picture of the process graphic display to the remote locations specified on the drawings as receiving facsimile copies of interrupting alarms.

3. For those points designated in paragraph 3 above, the FMCS shall also send a history log to the system report printer of the immediate prior history of the points causing the interrupt priority. This log shall contain 1 minute samples of the previous 15 minutes of operation.
4. For those points on the drawings designed as Hard Facts points, the Contractor shall provide an alarm message to a remote facsimile location designated by the Owner. The FMCS system shall provide at the remote location, a facsimile print-out showing location, time/date of alarm and alarm message of the point. For interrupt priority fax alarms, the remote facsimile machine shall receive a hard copy of the interrupt process screen showing on-line dynamic data values of the current conditions.

B. Off Hours Exception Reporting

1. The Owner shall specify up to five sites to which off hours exceptions shall be auto-dialed and reported. This shall allow the owner to assign off hours exception responses to various facility personnel as necessary. Selection of the site to be dialed can be programmed by the Owner, and set to change automatically per time of day and day of week.

2.15. MONITORING SYSTEM, SENSORS AND WIRING

A. Sensors and other Devices for Input/Output Summary Schedule:

1. Provide all necessary sensors, relays, panels, conduits and wire for the points indicated in the input/output summary as shown on the contract drawings.
2. Analog sensing elements for remote indication shall be independent of local sensors used for local control loops.

3. Temperature sensors shall be Resistance Temperature Detector (RTD) type of 1000 ohm balco. Space (60-90 degrees F); Duct/Well (-30-250 degrees F); Averaging Duct (-30-225 degrees F) or as required under Division 26.
 - a. Space temperature sensors shall be provided with blank commercial type locking satin chrome covers.
 - b. Duct temperature sensors shall be rigid stem or averaging type as specified in the sequence of operation. Water sensors shall be provided with a separable copper, monel or stainless steel well. Outside air wall mounted sensors shall be provided with a sun shield.
4. Relative humidity sensors shall be capacitance type with 10 percent to 90 percent range. Duct mounted humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with covers identical to temperature sensors. Space 10 percent -90 percent RH; Duct 10 percent - 90 percent RH.
5. All wall mounted temperature sensors, humidity sensors, and CO2 sensors shall be installed with stainless steel wire guard. Set point adjustment shall be achievable without removing the wire guard.
6. Differential and Static Pressure Sensors and Switches

Fan proof-of-flow switches shall be U.L. listed adjustable set point and differential pressure type. Switches shall be piped to fan discharge except where fans operate at less than one inch WG, they shall be piped across the fan. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inches WG. with .05-12 inch W.C. range.

 - a. Pump proof-of-flow switches shall be U.L. listed adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches shall have valved manifold for servicing, and a range of 3 psi-150 psi.
 - b. Air flow and static pressure analog sensors shall be high accuracy suitable for the low velocity pressures to be encountered, be selected for approximately 50 percent overrange, and have a 4 to 20 ma output. These differential pressure sensors shall be connected to the air flow measuring station with valved lines for testing and calibration, and shall have adjustments for zero and span. 5 inch W.C. range.
 - c. Water flow analog sensors shall be provided complete with flow element and shall be an all solid state precision industrial type with stainless steel meter body, maximum error of no more than .5 percent or span, and 4 to 20 ma output. Sensor shall be rated for 250 psi minimum and installed in strict accordance to the manufacturer's instructions complete with three-valve manifold for calibration and maintenance.
7. Overall system accuracy, including electronic analog sensing elements, shall be as follows:

- a. Air: Plus or minus 1.0 degrees F temperature, plus or minus 2.5 percent r.h., plus or minus 2.0 percent static pressure.
 - b. Water: Plus or minus 0.7 degrees F over full scale range for water points, plus or minus 1.0 degree F for others.
 - c. Proof of fan or pumps operating status, or alarm conditions shall be through positive feedback from differential pressure switches across fan or pump. Auxiliary dry contacts may be used for proof of fans or pumps if the motors are fractional H.P., and other non-ducted fans.
8. Digital inputs from devices with isolated, dry type contacts (no grounds, no voltage) of either normally open (N.O.) or normally closed (N.C.) configuration shall be provided. Live contact inputs, those that have voltage present, shall be provided with isolating devices to meet dry contact requirements.
9. Liquid flow data shall be received and transmitted by commercial grade instrument similar in quality to Honeywell 411, Rosemount, Foxboro, MAMAC Systems or approved equal, type differential pressure transmitter. Pulse type data sensors shall not be acceptable. Speed response of differential pressure transmitters shall be at least 500 milliseconds. Maximum error signal shall be +/- 1 foot.
10. Start-stop relay module shall contain relays for start-stop function at the remote point, with relays mounted and factory wired to numbered terminal strips.
11. Outage Devices:
 - a. Control Relays: Control relay contacts shall be rated for the application, with a minimum of two sets of Form C contacts, enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life-span rating of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression limiting transients to nondamaging levels.
 - b. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of two sets of Form C contacts enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices to limit transients to nondamaging levels. Delays contact opening or closing shall be adjustable from one to 60 seconds with a minimum accuracy of plus or minus 2 percent of setting.
 - c. Latching Relays: Latching relay contacts shall be rated for the application with a minimum of two sets of Form C contacts enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life-span rating of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to nondamaging levels.
 - d. Reed Relays: Reed relays shall be encapsulated in a glass-type container housed in a plastic or epoxy case. Contacts shall be rated for the application. Operating and release times shall be one millisecond or less. Reed relays shall have a minimum life span rating of 10 million operations.

- e. Contactors: Contactors shall be of the single-coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi-permanent magnets. Contacts shall be double-break silver-to-silver type protected by arcing contacts. Number of contacts and ratings shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices to limit transients to nondamaging levels.
- f. Solid-State Relays: Input-output isolation shall be greater than 1000 megohms with a breakdown voltage of 1500 V rms or greater at 60 Hz. The contact life shall be 10 million operations or greater. The ambient temperature range shall be minus 20 degrees to plus 140 degrees F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release times shall be one millisecond or less. Transient suppression shall be provided as an integral part of the relay to limit transients to nondamaging levels.

12. Audible Alarm:

- a. All alarms shall annunciate on the ATC system front end computer and via pagers.

2.16. MAKE-UP WATER FLOW METER/ALARM

- A. In-line T-mounted Flowmeter: Made for installation between pipe flanges; measures flow directly in gallons per minute. As manufactured by Aaliant, Badger, Hersey, Kele, Data Industrial or approved equal.
 - 1. Construction: Stainless steel body, with integral transmitter and direct - reading scale.
 - 2. Pressure rating: 400 psig maximum.
 - 3. Temperature Rating: 221 F maximum
 - 4. Display: Two lines; alphanumeric characteristic each. Visual instantaneous rate of flow, with register to indicate total volume in gallons.
 - 5. Output: Two simultaneous outputs; 4 to 20 mA, two-wire, pulse.
 - 6. Transmitter: Universal flow transmitter with pulse output (totalization) to convert digital pulses to totalized gallons.
 - 7. Electronic Housing: NEMA4, 3/4 NPT conduit connection, epoxy coated aluminum.
 - 8. Accuracy: Plus or minus 1 percent of reading.
 - 9. Key Pad: Setting of recalibration, engineering units, data logging sample time, alarms, response time.

- B. Power and control wiring to be furnished and installed under this Section of Division 23.

2.17. FLOW MEASURING STATIONS

- A. Furnish and install an Onicon Model F-1210, Hersey, Kobold or approved equal dual turbine insertion flow sensor complete with hot tap full port ball valve and installation hardware. The dual turbine element shall have counter rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Paddle type rotors will not be acceptable. Rotational sensing of each turbine shall be accomplished electronically by sensing impedance change and not with magnetic or photo-electric means. Each sensor shall be individually calibrated and tagged accordingly against the manufacturers primary standards which must be accurate to within 0.1 percent and traceable to the U.S. National Institute of Standards and Technology (NIST).
- B. The sensor shall have a maximum operating pressure of 400 PSI, maximum operating temperature of 220 degrees F (optional 300 degrees F) and a pressure drop of less than 1 PSI at 17 feet per second flow rate. Flow sensor shall have 100:1 turndown ratio. Accuracy shall be + 2 percent of actual reading from 0.4 feet per second to 20.0 feet per second.
- C. The sensor shall have integral analog outputs of 0-10 VDC and 4-20 mA current output for connection to the Central Control System. The sensor shall also include three integral frequency outputs, (top turbine, bottom turbine, average frequency) for diagnostic purposes and for connection to peripheral equipment (local display, BTU meter, etc.). All outputs shall be linear with flow rate.
- D. The turbine elements shall be made of polypropylene with sapphire jewel bearings and tungsten carbide shafts. The flow sensor shall be constructed of 316 stainless steel with an aluminum electronics enclosure and gasketed cover.
- E. Install flow measuring stations with minimum straight lengths of pipe upstream and downstream from sensor as prescribed by manufacturer's written instructions.
- F. Make electrical connections to power supply and interlock with ATC system.
- G. Calibrate meters for manufacturer's requirements.

2.18. FIELD INSTALLED CONDENSATE OVERFLOW SWITCHES

- A. Condensate overflow switches must be tested to comply with U.L. 508.
- B. Interlock condensate overflow switches to shut-down cooling equipment and alarm on ATC system where overflow condition exists.

2.19. CO2 SENSORS/TRANSMITTER

- A. Furnish and install wall mount CO2 sensor/transmitters at locations indicated on floor plans. CO2 sensor/transmitter shall be model CD-W00 as manufactured by Johnson Controls or approved equal.
- B. Measuring Range: 0 to 2,000 ppm CO2.

- C. Response Time: 1 minute
- D. Output Signal: As required by ATC system
- E. Max power consumption: Less than 2 watts.
- F. Listing: U.L. Listed
- G. Accessories: Mounting Kit, Transformer required.
- H. Where installed in toilet rooms, cafeteria, and corridors install heavy duty stainless steel guards.

PART 3. EXECUTION

3.1. GENERAL

- A. The Automatic Temperature Control System and Central Control and Management System, shall be designed, installed, and commissioned in a turnkey fully implemented and operational manner.

3.2. BMS SPECIFIC REQUIREMENTS

- A. Graphic Displays
 - 1. Provide a color graphic system flow diagram display for each new system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
 - 2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.
- B. Custom Reports:
 - 1. Provide custom reports as required for this project:

3.3. WORKSTATION INSTALLATION

- A. Desktop Workstations Installation:
 - 1. Install workstation(s) at location(s) directed by Owner.
 - 2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
 - 3. Install software on workstation(s) and verify software functions properly.
 - 4. Develop Project-specific graphics, trends, reports, logs and historical database.
 - 5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to

workstation.

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.4. INSTALLATION & SUPERVISION

- A. All wiring and tubing shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All piping and wiring within enclosures shall be neatly bundled and anchored to prevent restriction to devices and terminals.
- B. The control contractor shall be responsible for all electrical installation required for a fully functional control and automation system and not shown on the electrical plans or required by the electrical specifications. All wiring shall be in accordance to all local and national codes.
 1. All line voltage wiring, all wiring exposed, and all wiring in equipment rooms shall be installed in conduit in accordance to the electrical specifications.
 2. All electric and electronic wiring shall be minimum #20 AWG minimum THHN and shielded if required.
 3. All wiring in the central control room shall be concealed in an approved manner.
- C. Verify locations of temperature sensors, humidity sensors, CO2 sensors, and other exposed

control sensors with plans and Owner prior to installation.

- D. The installation and supervision of this project shall be carried out by factory trained personnel who are employed by the Contractor and licensed for this type of work.
- E. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
- F. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.
- G. Install in accordance with manufacturer's instructions.
- H. Check and verify location of space temperature sensors, humidity sensors, CO2 sensors, and other exposed control sensors with plans and room details before installation. Align with lighting switches and humidistats.
- I. Mount freeze protection thermostats using flanges and element holders.
- J. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
- K. Provide separable sockets for liquids and flanges for air bulb elements.
- L. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
- M. Install equipment plumb and level.
- N. Install all equipment to be accessible for service and maintenance.

3.5. ACCEPTANCE TESTING

A. Point Verification

To verify end-to-end operation of the system the Contractor shall provide a hard copy of an All Points Summary Listing to the Owner of each part or system to be placed in warranty by the Owner. For CHS systems, the Contractor shall additionally provide a print screen of the process display showing real time dynamic point information for all points on the subsystem(s) to be accepted.

B. Sequence Verification

- 1. The Contractor shall notify the Owner's representative of systems which perform all specified sequences.
- 2. The warranty acceptance test shall be of 5 days duration and the system shall perform as follows:

- a. During the five days, the FMCS system shall not report any system diagnostics from the subsystem under test.
- b. The subsystem shall be performance verified as operational using temporary trends of each control loop located in the SDC or MSDC.
- c. During the occupied periods, BAS control loops, under test, shall maintain control of the process variable within the following scales:
 - i. Duct Static Pressure ± 0.3 inch WC
 - ii. Pump Head Pressure ± 10 percent of control range
 - iii. Duct Temperature Loops ± 2 degrees F
 - iv. Room Temperature Loops ± 1 degrees F
 - v. Pipe Temperature Loops ± 2 degrees F
 - vi. Duct Humidity $\pm 2 \times$ rated error of Humidity Transmitter
- d. The contractor shall provide a hard copy printout of the process variable, process variable set point and control loop output percent for the period of 2 hours prior to occupancy to 2 hours after occupancy with samples taken every 15 minutes.

3.6. VARIABLE AIR VOLUME AIR BALANCING

- A. The air balance of the system shall be conducted by an independent AABC certified test and balance contractor.
- B. The test and balance contractor shall verify that duct static pressure and scheduled VAV box flows ± 5 percent are present at each VAV terminal and supply air system. The air balance contractor shall make such adjustments as necessary to verify air flows meet design requirements.
- C. The BAS contractor shall provide the air balance contractors via loan, palm top HHOT with an air balance test program. The HHOT shall plug into each wall sensor location and provide the air balancer a prompted display to properly set the minimum and maximum flow of each VAV terminal.

3.7. COORDINATE WITH TAB AGENCY

- A. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, freeze stats and duct smoke detectors.
- B. Verify that all controlling instruments are calibrated and set for design operating conditions prior to commencement of TAB work.
- C. Calibrate sensors after installation, and before the sensor control verification tests are performed. Prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditional space for each separately controlled zone.
- D. Allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing and balancing work can be performed.
- E. All control sequences, software, equipment, and components shall be started-up by a

qualified technician. Start-up report shall be submitted to Engineer prior to the commencement of testing and balancing work. Testing and balancing shall not commence until start-up reports are completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

3.8. EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that systems are ready to receive work.
- C. Beginning of installation means installer accepts existing conditions.
- D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.
- E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- F. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and tubing is installed prior to installation proceeding.

3.9. INTERLOCK REQUIREMENTS

- A. The fan and equipment interlock requirements are as scheduled on the contract drawings.
- B. Furnish and install all necessary relays, transformer, contactors, wiring, conduit, and accessories to perform fan, equipment, and damper interlocks.
- C. Unless otherwise noted, fan interlocks shall be arranged such that dampers associated with fan shall be open when fan starts and close when fan stops.

3.10. SUBMITTALS AT PROJECT CLOSEOUT

- A. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

3.11. CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Install piping adjacent to machine to allow service and maintenance.
- B. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

- C. Connect hand-off-auto selection switches to override automatic interlock controls when switch is in hand position.

3.12. FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 - 2. Test and adjust controls and safeties.
 - 3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 - 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 - 6. Test each system for compliance with sequence of operation.
 - 7. Test software and hardware interlocks.
 - 8. Test all end switches and verify status is reported on the ATC system.
- C. DDC Verification:
 - 1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 - 2. Check instruments for proper location and accessibility.
 - 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 - 4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
 - 5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 - 6. Check temperature instruments and material and length of sensing elements.
 - 7. Check control valves. Verify that they are in correct direction.

8. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.
- E. All temperature control and interlock wiring shall be installed in conduit unless otherwise noted on the plans. Power or interlock wiring shall be run in separate conduit from sensor and communications wiring.

3.13. ADJUSTING

- A. Calibrating and Adjusting:
 1. Calibrate instruments.
 2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
 3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
 4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using volt-ohm-milli-amp meter (VOMA) at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
 5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 0, p50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
 6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable

differential set at minimum.

7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
 8. Stroke and adjust control valves and dampers.
 9. Provide diagnostic and test instruments for calibration and adjustment of system.
 10. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature and humidity set points.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.14. ON-SITE ASSISTANCE

- A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.15. SCHEDULING

- A. Submit spreadsheet to Owner indicating occupied/unoccupied times for each item controlled by ATC system. Incorporate all scheduling requirements into sequence of operation.

3.16. STAGING

- A. Coordinate staging requirements with equipment being controlled. Where multistage units are scheduled or specified, provide all devices, controllers, wiring to control and sequence all stages.

3.17. VRF/VRV SYSTEMS INTEGRATION

- A. For VRF/VRV systems the building automation system contractor shall:
1. Supply all the application software to read and write all points available from the VRF/VRV systems BACnet gateway.
 - 1.
 2. Supply all physical points for the VRF /VRV equipment not supplied by the VRFVRV systems BACnet gateway to meet the sequence of operation and control

strategy of the Building Automation Systems.

3. Not exceed the maximum read writes to points for the yearly buffer and storage of data limits for the VRF/VRV equipment.
4. Request the timing requirements for the loading of communications between Building Automation Systems and VRF/VRV Systems BACnet gateway limitation.
5. Additionally, the Building Automation System shall be capable of providing daily, weekly, yearly, and holiday programmable scheduling of Occupied/Unoccupied settings, On/Off, Mode of Operation, set point and fan speed based on the available functions of the connected VRF/VRV systems.

END OF SECTION

DIVISION 23 SECTION 233000
HVAC AIR DISTRIBUTION
TABLE OF CONTENTS

PART 1. GENERAL.....	1
1.1. SUMMARY	1
1.2. REFERENCES	1
1.3. PERFORMANCE REQUIREMENTS	2
1.4. QUALIFICATIONS	2
1.5. REGULATORY REQUIREMENTS.....	2
1.6. ENVIRONMENTAL REQUIREMENTS	2
1.7. ALTERNATES.....	2
PART 2. PRODUCTS.....	2
2.1. DUCTWORK	3
2.2. DUCT SYSTEMS	4
2.3. DUCT CONSTRUCTION	4
2.4. CONDENSING BOILER INTAKE DUCTWORK (PIPING) MATERIAL	5
2.5. AIR TRANSFER OPENINGS	5
2.6. AIR VOLUME CONTROLS	5
2.7. INSTRUMENT TEST PORTS	6
2.8. DUCT THERMOMETERS	6
2.9. FIRE DAMPERS	7
2.10. DUCT ACCESS DOORS	8
2.11. SPIN-IN FITTINGS.....	8
2.12. DUCT LINING (LOW PRESSURE DUCTWORK)	8
2.13. STACKS AND BREECHING (CONDENSING BOILERS)	9
2.14. AIR TERMINAL DEVICES.....	10
2.15. LOUVERS (FIXED BLADE).....	13
2.16. LOUVER BLANK-OFF PANELS	13
2.17. OPEN END DUCTS (OED).....	13
2.18. DRIP PANS	14
2.19. DUCT SEALANTS AND ADHESIVES	14
2.20. AUXILIARY DRIP PANS	15
2.21. FILTER MEDIA DURING CONSTRUCTION	16
PART 3. EXECUTION.....	16
3.1. DUCT INSTALLATION REQUIREMENTS	16
3.2. ACCESSORY INSTALLATION REQUIREMENTS.....	17
3.3. DUCT LINING INSTALLATION REQUIREMENTS.....	18
3.4. BOILER STACKS AND BREECHING INSTALLATION REQUIREMENTS.....	19
3.5. CONDENSING BOILER INTAKE DUCT INSTALLATION REQUIREMENTS.....	20
3.6. CLEANING	21
3.7. LEAKAGE TESTS	21
3.8. DUCTWORK IDENTIFICATION.....	21

SECTION 23 30 00

HVAC AIR DISTRIBUTION

PART 1. GENERAL

1.1. SUMMARY

- A. For General Mechanical Requirements, see Division 23 Section, "Common Work Results for HVAC" and Division 01, "General Requirements".
- B. The fabrication and installation of all ductwork, together with related equipment, shall comply with the standards of the National Fire Protection Association, as set forth in NFPA Standard No. 90A, as well as with the requirements of the Sheet Metal and Air Conditioning Contractors' National Association, Inc., and the latest edition of the ASHRAE Guide.
- C. All duct sizes shown are net inside clear dimensions. Where internal duct lining is used, increase duct sizes accordingly to provide the indicated net free area. Unless otherwise indicated size runouts, drops, and connections to grilles, registers, diffusers, fans, coils, louvers, filters, and other equipment to the full size of the equipment connection.
- D. Minor changes may be made in duct sizes where required to fit the available space, provided the indicated net free area and approximate aspect ratio are maintained.
- E. Smoothly transition all ductwork to prevent excessive or unnecessary turbulence or pressure loss.
- F. All exposed ductwork in finished areas shall be painted in color as indicated by Architect. All ductwork requiring paint shall be constructed of paint grade galvanized sheet steel with a paintable finish.

1.2. REFERENCES

- A. ASTM A 36 - Structural Steel
- B. ASTM A 90 - Weight of coating on Zinc-Coated (Galvanized) Iron or Steel Articles
- C. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- D. ASTM C 916 Type II – Standard Specification for Adhesives for Duct Thermal Insulation
- E. ASTM A 366 - Steel, Sheet, Carbon, Cold Rolled, Commercial Quality
- F. ASTM A 480 - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
- G. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
- H. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality

- I. ASTM A 568 - Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled
- J. ASTM A 569 - Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality
- K. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate
- L. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- M. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems
- N. SMACNA - HVAC Air Duct Leakage Test Manual
- O. UL 181 - Factory-Made Air Ducts and Connectors.
- P. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- Q. NFPA 70 - National Electrical Code
- R. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
- S. UL 33 - Heat Responsive Links for Fire-Protection Service.
- T. UL 555 - Fire Dampers and Ceiling Dampers

1.3. PERFORMANCE REQUIREMENTS

- A. No variation of duct configuration or sizes permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE Table of Equivalent Rectangular and Round Ducts.

1.4. QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the projects specified in this section with minimum five (5) years documented experience.
- B. Installer: Company specializing in performing the work of this section with minimum five (5) years' experience.

1.5. REGULATORY REQUIREMENTS

- A. Construct ductwork to NFPA- 90A, and NFPA-90.

1.6. ENVIRONMENTAL REQUIREMENTS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturer.
- B. Maintain temperatures during and after installation of duct sealants.

1.7. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. DUCTWORK

- A. Unless otherwise indicated or specified, fabricate ductwork of galvanized sheet steel, stainless steel, or aluminum conforming to Commercial Designation 3003 Temper H14 and Duct Sheet. Duct gages, jointing and reinforcement shall conform to Tables 4, 5, 6 and 7, as applicable, Chapter I of the latest ASHRAE Guide and Data Book. Construction details shall conform to Section I and Section II, as applicable, of Duct Manual and Sheet Metal Construction for Ventilation and Air Conditioning Systems as published by Sheet Metal and Air Conditioning Contractors' Association, Inc.
- B. Erect sheet metal ductwork in a first-class, workmanlike manner secured in place rigidly and permanently. Provide suitable hangers, securely attached to building construction with bolts, clips or inserts. Hangers shall be structural shapes, flat bars, or formed strap hangers; use of wire will not be permitted. Hangers shall not pass through or be inside duct. Support vertical ducts passing through floors by angles riveted to duct and resting either on floor or on brackets secured to building construction. All space around ducts where they pass through any walls, floors, ceilings, or roofs shall be sealed tight with incombustible inert material. Do not arrange ducts so as to impair the effectiveness of fireproofing around structural members. Provide sheet metal flanged collars around exposed ducts passing through walls, floors, or ceilings to provide finished appearance. Seal all duct joints and seams including supply, return, outside air, combustion air, relief air, ventilation air and exhaust ductwork with Hardcast Sealing System as manufactured by Hardcast, Inc., Foster, Childers, or approved equal.
- C. Flexible connections of neoprene or other NFPA approved non-inflammable fabric shall be provided in the duct system at all fan inlet and outlet connections.
- D. Provide cut turning vanes in all duct turns where centerline radius is located. Turning vanes shall be air-foil type with extended trailing edges. Fabricate to comply with SMACNA Sheet Metal Construction for Ventilation and Air Conditioning Systems Manual.
- E. Provide duct collars and angle iron framework for mounting of automatic dampers.
- F. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- G. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
- H. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- I. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4-inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.

- J. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.
- K. Fasteners: Rivets, bolts, or sheet metal screws.
- L. Hanger Rods: ASTM A36 - Galvanized steel; threaded both ends, threaded one end, or continuously threaded.

2.2. DUCT SYSTEMS

- A. All supply, return, exhaust, fresh air intake, relief, ventilation, outside air and combustion air ductwork shall be constructed for low pressure service (2 inch W.G.).

2.3. DUCT CONSTRUCTION

- A. Rectangular and/or Round Ductwork (Low Pressure):
 - 1. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having G-90 Zinc coating in conformance with ASTM A90.
 - 2. Make allowance for internal duct lining where required. Sizes shown on the drawings are inside clear dimensions.
 - 3. Determine duct gauges for the longest duct side and use for all four sides. Joints and reinforcing requirements apply to the longest duct side.
 - 4. Reinforce all ducts to prevent buckling, vibration, or noise as recommended in the referenced construction standards, and as required to suit the installed conditions.
 - 5. Do not cross break duct which will receive rigid insulation covering.
 - 6. Where tap sizes of divided-flow fittings are not indicated, make branch and main/connection sizes proportional to their respective air flows and maintain uniform transverse velocities in the fitting.
 - 7. Make radius elbows and radius tee connection with throat radius equal to or greater than the width of the duct. Use vaned elbows where shown and where radius elbows will not fit the space, and in all square bends.
 - 8. Turning vanes shall be the air-foil type with extended trailing edges, 36-inch maximum vane length. Where longer vanes are required, use two or more sets of vanes with intermediate runners securely fastened together.
 - 9. Bolt, screw, rivet, or spot weld reinforcing members securely to the duct on not less than 6-inch centers.
 - 10. Where ducts are open-ended without grilles, registers, or other means of stiffening, reinforce and stiffen the open end with standing seams or an angle frame. Provide rolled edges to prevent any exposed sharp edges.
 - 11. Paint all cut ends on galvanized angles, rods, and other uncoated surfaces with aluminum paint.
 - 12. Where ductwork is not painted or otherwise finished, remove all exposed traces of joint sealers, manufacturer's identification and other markings.

13. Aluminum sheet shall be 3003 H14 alloy or duct sheet, 16,000 psi minimum tensile strength, and capable of being formed to a Pittsburgh lock seam.
14. Reinforcing members for aluminum ductwork shall be galvanized steel or aluminum unless otherwise indicated. Where aluminum reinforcing is used, size the member in accordance with ASHRAE recommendations to have rigidity equivalent to listed mild steel angle sizes.
15. Where aluminum ductwork is used, make allowance for increased thermal expansion. Particularly avoid direct contact between aluminum and concrete or masonry walls subject to dampness.
16. Determine duct gauges per SMACNA based on duct size and pressure indicated.

2.4. CONDENSING BOILER INTAKE DUCTWORK (PIPING) MATERIAL

- A. Intake Piping – PVC Pressure Pipe: ASTM D2665, solid wall drain, waste and vent (schedule 40).
 1. PVC Socket Fittings: Schedule 40 PVC, ASTM F89 socket fittings.
 2. Joints: Solvent weld with solvent cement.
 3. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 4. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5. AIR TRANSFER OPENINGS

- A. Furnish and install metal sleeves or frames, of the same material as the duct or air terminals attached thereto, in all air transfer openings through walls, partitions, floors and other building construction, extending completely through the opening. Securely fasten the sleeves or frames in place and provide face flanges on both sides. Where grilles or registers are required, attach them to the sleeve or frame, or extend ductwork where shown on the drawings. If no grilles, registers or duct connections are required, furnish and install ½ inch x ½ inch removable galvanized wire mesh on one face.

2.6. AIR VOLUME CONTROLS

- A. Furnish and install air volume control devices where indicated and where required to adjust and balance air flow in the systems, whether indicated or not. Volume dampers shall be provided in all branch ducts serving air outlets and inlets. For existing air devices install a new volume damper and where required for access, a new access door to allow access and adjustment.
- B. Air extraction for air outlets and branch ducts shall be the gang-operated vane type, Tuttle & Bailey - Vectrol, Type VLC or VLK as appropriate, or approved equal, with suitable adjusting device and means of access.
- C. Manual volume dampers in ductwork shall be factory-assembled units with rigid frame, opposed-blade action, and locking quadrant operator. Mark the extended damper shaft and align the operating handle to indicate the blade position. Dampers shall be as

manufactured by Ruskin, American Warming and Ventilating, Inc., Arrow, or approved equal. Rectangular dampers shall be Type MD35, with steel channel frame, 16 gauge steel blades, 9 inch maximum blade spacing, low pressure, nylon bearings, galvanized finish with aluminum paint touch up. Round manual balancing dampers shall be Type MDRS25 manufactured by Ruskin, Arrow, American Warming and Ventilating, Inc., or as approved equal. When external insulation is to be applied, provide sheet metal standoffs on all manual volume dampers.

- D. Motor-operated dampers shall be as hereinafter specified under Division 23 Section, "Instrumentation and Controls of HVAC & Plumbing System".
- E. Duct turning vanes shall be Tuttle & Bailey Ducturns, or approved equal.
- F. Furnish and install duct collars and angle iron frames for the installation of ATC dampers.
- G. Where volume dampers are installed in exposed finished spaces locate damper handle on top of duct.
- H. Where volume dampers are installed above ceilings attach a colored piece of tape so that Test and Balance Engineer can easily locate for air flow adjustment.

2.7. INSTRUMENT TEST PORTS

- A. Furnish and install instrument test ports in the ductwork to allow use of pitot tube length. Equip holes with Ventlok #699 instrument ports. Fittings shall extend beyond duct covering and insulation.

2.8. DUCT THERMOMETERS

- A. Duct thermometers shall be Dresser Industries, Terrice, Weiss, Weksler, Miljoco, or approved equal direct-mounting filled system dial thermometers. Duct thermometers shall be vapor-actuated, universal-angle dial type, cast aluminum case with 4 ½ inch diameter, glass lens. Duct thermometers shall include adjustable joint with finish to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, with locking device. Thermal bulbs shall be copper with phosphor-bronze bourden pressure tube. Movement shall be brass, precision geared. Duct thermometer scales shall be Progressive, satin-faced non-reflective aluminum with permanently etched markings. Each stem shall be copper-plated aluminum or brass for separable socket of length to suit installation.
- B. Where ductwork is installed at a height that would require duct thermometers to be installed 10 feet above finished floor or greater then remote-ready filled - system dial thermometers shall be installed. Connecting tubing shall be bronze, double-braided, armor-over-copper capillary; of length to suite installation.
- C. Duct thermometers shall be furnished and installed at air handling units, energy recovery ventilators, geothermal rooftop heat pumps, and ducted variable refrigerant volume units as follows:

LOCATION	RANGE
Outdoor Air Duct	-40 degrees Fahrenheit to 120 degrees Fahrenheit
Return Air Duct	40 degrees Fahrenheit to 180 degrees Fahrenheit
Mixed Air Plenum	30 degrees Fahrenheit to 180 degrees Fahrenheit
Supply Air Duct	30 degrees Fahrenheit to 180 degrees Fahrenheit
Exhaust Air Duct	30 degrees Fahrenheit to 180 degrees Fahrenheit

- D. Description: Flanged fitting bracket for mounting in hole of duct, with threaded end for attaching thermometer.
1. Extension Neck Length: Nominal thickness of 2 inches, but not less than thickness of exterior insulation.
 2. Insertion Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation lining.

2.9. FIRE DAMPERS

- A. Furnish and install automatic fire dampers where indicated, in all 2-hour fire-rated partitions, shafts, slabs, etc., and where required by NFPA Standard No. 90A and by the Fire Marshal. Refer to the architectural drawings for location of all fire-rated walls, shafts and slabs. Fire Dampers shall also be provided at all transfer air devices installed in rated walls at all floor penetrations, and as shown on the contract drawings.
- B. Construction of fire dampers shall conform to requirements of NFPA No. 90A, UL Standard 555 and shall bear UL label. Fire dampers shall be set in frames adequately secured to fire partitions, floors, etc., and installed in strict accordance with UL listing and manufacturer's instructions.
- C. Fire damper shall be Dynamic Type for rectangular ductwork and round ductwork as manufactured by Ruskin, Air Balance, Inc., Arrow, Greenheck, Lloyd Industries, Nailor, or approved equal, multi-leaf accordion type, held open by adequate heavy gauge wires and suitably calibrated fusible links. Vertical dampers (horizontal air flow) shall close by gravity. Horizontal dampers (vertical air flow) shall be closed by suitable and positive spring closing devices.
- D. Damper frames shall provide pocket which shall store the damper leaves in open position outside of the air stream and shall provide for 100 percent opening connecting to ductwork or grille face. Damper material shall match connecting ductwork.
- E. Provide adequately sized hinged access doors with cam locks for access to all fusible links and for resetting fire dampers. Where applicable, access to fire dampers shall be through registers or grilles. Provide identification on access door indicating fire damper within. Letters shall be not less than ½-inch in height.

- F. Submit complete information to the Engineer including installation details. Furnish and install sleeves, angles, break-away duct connections, per UL listing.
- G. Furnish to the Owner in a suitable storage container not less than six (6) fusible links of each type, size, and rating used on the project. Where required, furnish Greenheck Type CR, CO, or Type C transition sleeves.

2.10. DUCT ACCESS DOORS

- A. Furnish and install adequately sized duct access doors at fire dampers, smoke dampers, air measuring devices, motor-operated dampers, and duct smoke detectors and other locations where indicated and required for duct access. Doors shall be the continuous piano-hinged type with approved latches and neoprene compression-type gaskets with 1 inch thick fiberglass double skin and shall be Ruskin Model ADH22, Air Balance, Inc., FSA-100 or as approved equal. Stiffen ductwork at door openings. Where doors are installed in insulated ductwork, provide equivalent insulation in the door assembly. Where access doors are installed in the fire-rated partitions, provide Fire Seal access doors as manufactured by Air Balance, Inc., or approved equal, UL approved, meeting the rating of the enclosure in which the access door is installed.
- B. Where duct access doors are installed in medium pressure ductwork, they shall be as manufactured by Ruskin, Type ADHP-3, or approved equal, with six latches continuous gasket and insulated core.
- C. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

2.11. SPIN-IN FITTINGS

- A. Furnish and install spin-in fittings where indicated on the contract drawings, Model SM-20G, as manufactured by General Environment Corporation, or an approved equal.

2.12. DUCT LINING (LOW PRESSURE DUCTWORK)

- A. All low pressure supply and return ductwork within 10 feet of air handling units, rooftop units, energy recovery ventilation units, geothermal heat pump units, single zone VAV units, and as additionally shown on Contract Drawings, shall be lined on the interior for sound attenuation and thermal insulation.
- B. All low pressure ductwork within 10 feet of return [or exhaust] air fans and as additionally shown on Contract Drawings shall be lined on the interior for sound attenuation and thermal insulation.
- C. All internal duct lining for low pressure duct systems shall be provided with an interior galvanized perforated liner.
- D. Provide additional exterior insulation where required and as indicated in Division 23 Section, "HVAC Insulation".
- E. The lining insulation shall be 1 inch thick, 3.0 pcf density, Aeroflex plus Duct Liner Type 300, Owens Corning Quiet R Rotary Duct Liner, Manville, Knauf, or approved equal. The material shall be specifically designed for this application, shall have a black, fire-

resistant coating, shall meet NFPA Standards 90A and 90B and shall have a UL Fire Hazard Classification of Flame Spread 25 or less and smoke developed of 10 or less. The black-coated surface shall face the air stream.

- F. All exposed edges and the leading edge of all cross joints of the liner shall be coated with the same adhesive used to secure the duct liner to metal surface. All air stream surfaces shall be treated with EPA registered fungicide Foster 40-20. Coating shall meet ASTM D 5590 with 0 growth rating.
- G. The duct liner shall be adhered to the metal with 100 percent coverage of adhesive. Adhesive shall conform to Adhesive and Sealant Council Standards for adhesives for duct liner; ASTM C916, Type II (ASC-A-7001-A-1971). Adhesive shall be Foster 85-60, Childers CP-127 or approved equal.
- H. The duct liner shall be additionally secured with mechanical fasteners, which shall compress the duct liner sufficiently to hold it firmly in place. Mechanical fasteners shall conform to Mechanical Fastener Standard MF-1-1971, available from Sheet Metal and Air Conditioning Contractors National Association.
- I. All duct lining shall be installed in complete accordance with the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Duct Liner Application Standard, First Edition and Green Guard Indoor Air Quality certification program requirements.
- J. Dimensions on drawings indicate inside clear opening of rectangular ductwork. Increase duct dimensions 2 inches each way for accommodating insulation on all shop or field-fabricated rectangular ductwork where lining is specified.

2.13. STACKS AND BREECHING (CONDENSING BOILERS)

- A. The factory-built modular connector, manifold and breeching system shall be laboratory-tested and listed by Underwriters Laboratories, for use with building heating equipment which produces exhausted flue gases at a temperature not exceeding 550 degrees Fahrenheit (F) under continuous operating conditions and shall comply with UL-1738, ULC 5636, NFPA-54, and NFPA-211 when burning gaseous, solid or liquid fuels as described in NFPA 211. The breeching system shall be designed and installed to be gas and water tight and thus prevent leakage of combustion products into a building. The system shall be designed to compensate for all flue gas induced thermal expansions.
- B. Vent shall be factory-built special gas type, double wall, engineered and designed for use on Category I, II, III, and IV appliances, or as specified by the equipment manufacturer.
- C. The double wall breeching shall have an inner gas carrying pipe of Type AL29-4C stainless steel for natural gas. Vent shall be listed for an internal static pressure of 15" w.g. and tested to 37" w.g. There shall be a nominal 1-inch fiber insulation between the walls. The outer jacket shall be Type 430 stainless steel. The materials and construction of the modular sections and accessories shall be as specified by the terms of the product's UL listing.
- D. The stack system shall be installed according to the manufacturer's installation instructions and shall comply with the codes and standards of the State of Delaware,

International Mechanical Code, and applicable N.F.P.A. pamphlets. Stack termination height shall be sufficient to prevent re-entrainment into other building openings. Stack termination shall be minimum of 15 feet away from all building openings, intakes. All breeching stack terminations with a 15 foot radius of any building opening intake, or louver shall be extended 3 feet above the opening, intake or louver.

- E. Inner wall joints shall be designed with a male and female overlapping metal-metal connection to maintain condensate in the AL29-4C stainless steel. Proper ¼" per foot pitch must be maintained at all times and condensate should flow back toward the appliance to the required number of drains. All inner wall conduit components shall be manufactured from AL-29-4C stainless steel. The joint closure system shall be an inner wall mechanical locking strap design. Joints shall not use screws or fasteners that penetrate inner conduit.
- F. When installed according to the manufacturer's installation instructions, the piping and its supporting system shall resist side loads (whether system is horizontal or vertical) at least 1.5 times the weight per foot of the piping. Wall supports shall support 40 feet of pipe with a factor of safety of at least four (4). Plate supports shall support (as verified by manufacturer testing) 200 feet of pipe in 6-inch through 20-inch ID sizes and 100 feet of pipe in 24-inch ID and larger sizes with a factor of safety of at least four (4).
- G. The entire breeching system from the equipment to termination, including all required accessories (ventilated roof thimbles, guy wires, storm collar, guy tensioners, expansion joints, discharge cone, supports, etc.), shall be from one manufacturer.
- H. The breeching shall be warranted against functional failure due to defects in material and manufacturer's workmanship for a period of fifteen years from date of installation. Drawings showing the actual layout and drawn to scale shall be provided by the manufacturer. The system shall be installed as designed by the manufacturer and in accordance with the terms of the manufacturer's 15-year warranty and in conjunction with sound engineering practice. The inner diameter for breeching and stacks shall be verified by the manufacturer's computations. The computations shall be technically sound, shall follow ASHRAE calculation methods, and incorporate the specific flow characteristics of the inner pipe. The Contractor shall furnish the exact boiler model and operating characteristics to the factory representative. Operating characteristics shall include flue gas flow rate, BTU input, outlet temperature, local altitude, stack layout, and available external pressure at boiler or equipment outlet, etc., necessary to determine system operation at maximum and minimum levels of burner turndown range.
- I. Boiler or equipment breeching, as hereinbefore specified, shall be provided for all new fuel-fired equipment, including but not limited to boilers.
- J. General Electric RTV106 (aka Mumentive) or Dow Corning 736 High Temperature Sealant shall be used to seal all joints on systems where the maximum flue gas temperature will not exceed 550°F.
- K. Boiler breeching shall be Type Saf-T Vent CI Plus as manufactured by Selkirk Metalbestos, Type CS Plus by Van Packer, Type SD by Schebler, or Type CG by Metal-FAB.

2.14. AIR TERMINAL DEVICES

- A. Furnish and install air supply, return, exhaust devices of sizes and capacities as scheduled on the drawings. Catalog numbers shown are Metalaire, Inc., products for equipment which have been found suitable for the application. Products of Tuttle & Bailey, Anemostat, Division of Hart & Cooley, Carnes, Titus, Price, Nailor, Krueger, or approved equal will be considered only if performance characteristics including throw, drop, pressure loss, sound pressure level, etc., are equal to or better than the performance characteristics of the specified products. All air devices shall be ADC certified. Ductwork behind registers, grilles and diffusers shall be given two coats of flat black paint. Perimeter of all ceiling diffusers shall be caulked to provide a neat, aesthetic appearance.

B. Device Schedule:

AIR DEVICE SCHEDULE		
Device	Accessories	Finish
Supply Diffusers, Lay-in Tile		
Model 5000-A, Rectangular MetalAire Ceiling Diffuser, Throw as Indicated	Integral opposed blade damper	White baked enamel finish
	Removable core	
	Louvered face	
	All aluminum construction	
	Auxiliary panel for lay-in tile installation	
	Adjustable pattern deflector	
Supply Diffuser, Gypboard, Surface Mount		
MetalAire Model 5000-A, Rectangular Ceiling Diffuser, Throw as Indicated (Surface or Duct Mount)	Integral opposed blade damper	White baked enamel finish
	Louver face	
	All aluminum construction	
	Removable core	
	Adjustable pattern deflector	
Linear Slot Diffuser, Ceiling Mount		
Titus Flowbar Model FL-15-HT Continuous Linear Slot System	All aluminum construction	Natural aluminum finish.
	Insulated Plenum	

AIR DEVICE SCHEDULE		
	Adjustable pattern control dampers	
Return/Exhaust, Transfer Register, Gypboard, Surface Mount		
MetalAire, Model RHD Rectangular Registers (Surface Mount)	Integral opposed blade damper	Off-white baked enamel finish
	45 degree angled deflecting vanes	
	All aluminum construction	
Return/Exhaust, Transfer Register, Lay-in Tile		
MetalAire, Model RHD Rectangular Registers	Integral opposed blade damper	Off-white baked enamel finish
	45 degree angled deflecting vanes	
	All aluminum construction	
	Auxiliary panel for lay-in tile installation	
	Provide return air filters racks and 1" thick filters where indicated.	
Supply Diffuser Round, High Capacity		
MetalAire Model 3100 Round Ceiling Diffusers	Air equalizing grids	Off-white baked enamel finish
	Integral opposed blade dampers	
	Volume control adjustment	

- C. Where air terminal devices are installed in duct collars or branches, furnish and install air extractors. Furnish and install control grids, volume dampers, and/or other accessories necessary to ensure uniform air flow across the terminal devices. Accessories shall be of the same material as the terminal device. Install fixed blade terminals so that blades block the normal line of vision. Furnish three (3) of each type of removable key operators.
- D. Contractor shall determine frame and mounting type as per type of ceiling as shown on Architectural drawings.
- E. Noise Criteria: All air devices shall be sized and selected to limit maximum NC (noise criteria) levels to 30.

2.15. LOUVERS (FIXED BLADE)

- A. Furnish and install wall louvers of the size and capacity shown on the contract drawings. Louvers shall be Greenheck Model EHV-901 (high velocity wind driven rain) heavy gauge extruded aluminum stationary type louvers or approved equal. Louvers shall be stationary, dual module type consisting of a “front” louver with J-style blades and a “rear” louver with vertical rain resistant style blades. Louver frame shall be a total depth of 9 inches.
- B. Front louvers shall be drainable type fabricated from heavy gauge 6063-T5 aluminum extrusions of .081 inch nominal wall thickness. Blades shall be positioned at 37 degree and 45 degree angles, approximately 4.25 inches on centers. Rear louver shall be vertical rain resistant style, heavy gauge extruded 6063-T5 aluminum, 0.060 nominal thickness, positioned on approximately 1.5 inch blade spacing. Each louver shall be equipped with a frame and removable rear-mounted screen of flattened aluminum. Each factory assembled louver section shall be designed to withstand wind loadings of 25 psf. Louvers too large for complete factory assembly shall be built up by the installing contractor from factory assembled louver sections.
- C. Louvers shall be tested in accordance with AMCA 550-L, AMCA-540, and AMCA 550 (Certified High Velocity, Rain Resistant, and Impact Resistant Louver).
- D. Louvers shall be supplied with a factory Kynar finish applied after a thorough cleaning and preparation of the metal surface. A total dry film thickness of approximately 1.2 mils shall be provided. Custom color shall be as selected by Architect.
- E. Louvers shall be provided with ¼ inch x ¼ inch aluminum bird screens, factory-furnished and installed. Louver performance data shall be A.M.C.A. certified. All louvers shall be caulked weathertight around entire perimeter.

2.16. LOUVER BLANK-OFF PANELS

- A. Insulated, Blank-Off Panels: Laminated panels consisting of insulating core surfaced on back and front with metal sheets and attached to back of louver
 - 1. Thickness: 2 inches (50mm)
 - 2. Metal Facing Sheets: Aluminum sheet, not less than .032 inch (.81mm) nominal thickness.
 - 3. Insulating Core: Rigid, glass-fiber-board insulation or extruded-polystyrene foam
 - 4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames, not less than .080 inch (2.03mm) nominal thickness with corners mitered and with same finish as panels.
 - 5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
 - 6. Panel Finish: Same finish applied to louvers.
 - 7. Attach blank-off panels with stainless steel sheet metal screws.
 - 8. Cover all unused openings in louvers.

2.17. OPEN END DUCTS (OED)

- A. Whether indicated on plans or not, all open-ended ducts shall be provided with a protective screen.
- B. All open-ended ducts shall be furnished with a 12 gauge ½ inch x ½ inch aluminum mesh screen. Screens shall be permanently installed in a removable frame, and the frame shall be attached to the open-ended duct in a neat, workmanship-like manner without any exposed edges or sharp surfaces.
- C. Screen shall be attached to a ¾ inch x 1/8 inch continuous galvanized perimeter frame. Install duct stiffeners greater than 16 inches in any direction at open-ended ducts.

2.18. DRIP PANS

- A. Furnish and install suitable watertight, aluminum drip pans where water or drain piping is routed over electrical switchgear, transformers, computers, elevator machine equipment, dry storage rooms, etc. Each drip pan shall have a 1 inch copper type M drain piped to discharge where shown on drawings; or, if not shown, to discharge over nearest available open drain. Size and arrangement shall be as approved by Engineer. Sides shall be minimum 1.5 inches deep.
- B. Drain pans shall be of 16 gauge welded construction. Provide drawings of typical drain pan construction for approval before construction. See Submittals in Division 01 Section, "Product Requirements".

2.19. DUCT SEALANTS AND ADHESIVES

- A. All ductwork shall be sealed, including low pressure exhaust systems. Transverse joints and longitudinal seams in duct systems shall be sealed with a duct sealant of the type specified hereinafter in Section 1, 2, or 3, or with a tape sealing system as specified in Section 4. Spiral lockseams are not longitudinal seams and do not require duct sealant. All seams and joints shall require duct sealant suitable for the pressure rating and installation application. All sealants shall exceed 500 hours without becoming brittle under ASTM-D572 test conditions (oxygen bomb), unless specified otherwise. No surface preparation or solvent cleaning shall be necessary to remove light coatings of oil and dust before applying sealant unless specified otherwise. Flanged joints shall be sealed according to Section 5. Construction joints that are not fully welded shall be sealed according to Section 6. Adhesive to secure insulation to metal surfaces shall be that specified in Section 7.
 - 1. Assembly joints to be installed indoors or outdoors shall be sealed with Foster 32-19, Childers CP-146, United Duct Sealer WB, or equivalent, which is a water-based sealant formulated to withstand service temperatures from 20 degrees F to +200 degrees F. Sealant shall have a UL Classification marking with a flame spread of 15 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 31 square feet per gallon. Store and apply between 40°F (4°C) and 100°F (38°C); protect from freezing.
 - 2. Assembly joints to be installed indoors shall be sealed with Foster 32-19, childers CP-146, UNI-GRIP™ duct sealer or equivalent, which is a water-based (vinyl-acrylic polymer) sealant formulated to withstand temperatures from -20 degrees to +200 degrees Fahrenheit. Surfaces to be sealed should be clean, dry, and free from oil, grease, and dirt. Sealant shall be nonflammable (wet) and fire retardant.

Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 5 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 40 square feet per gallon.

3. Assembly joints shall be sealed with UNI-CAST® tape sealing system or equivalent, which is a combination of an adhesive activator and woven-fiber tape impregnated with a gypsum mineral compound. Modified acrylic/silicone activator (MTA-20 for indoor use) reacts exothermically with the tape to form a hard, airtight seal. Sealant shall be formulated to withstand temperatures from –40 degrees F to +200 degrees Fahrenheit. Combination of tape and MTA-20 adhesive shall have a flame spread and smoke developed of 0. Do not use for outdoors.
4. Flanged joints to be installed indoors shall be sealed with UNI-GASKET™ flange sealer or equivalent, which has a synthetic elastomer base and is formulated to withstand temperatures from –20 degrees F to +150 degrees F. Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 5 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 5 when applied to inorganic reinforced cement board, both at a coverage of 80 square feet per gallon.
5. Where duct fittings are constructed with standing seam or spot-welded techniques, all construction joints shall be sealed with UNI-WELD™ metal cement or equivalent, which is composed of neoprene rubber, resins, and inert reinforcing material dispersed in a petroleum distillate. Sealant shall be formulated to withstand temperatures from –20 degrees F to +225 degrees F. Sealant shall have a UL Classification marking with a flame spread of 0 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, tested as applied in two 1/8 inch beads 8 inches on center.
6. Where insulation is to be secured to metal surfaces, the adhesive used shall be Foster 85-60, Childers CP-127, UNI-TACK™ duct liner adhesive or equivalent, which are water-based, vinyl-acrylic copolymer adhesives formulated to withstand temperatures from –20 degrees Fahrenheit to +200 degrees Fahrenheit. Adhesive shall have a UL Classification marking with a flame spread of 0 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 267 square feet per gallon. Adhesive shall conform to ASTM C916, Type II.

- B. Manufacturers: Duct Mate, United McGill, MKT Metal Manufacturers, Semco, Elgen, Childers, Foster, or as approved equal.

2.20. AUXILIARY DRIP PANS

- A. Furnish and install suitable watertight, aluminum drip pans for all suspended air handling units, heat pumps, or air handling units installed on upper floor and/or attic. Each drip pan shall have a 1" copper type "M" drain piped to discharge where shown on drawings. Drain pan shall extend 3" beyond sides of air handling unit/heat pump. Sides shall be minimum 1.5" deep.
- B. Drain pans shall be of 16 gauge welded construction. Provide drawings of typical drain

pan construction for approval before construction. See Submittals, Division 23 Section, "Common Work Results for HVAC" and Division 01, Section, "General Requirements".

- C. Install U.L. 580 listed condensate float switch in auxiliary drain pan and wire to shut-down unit upon sensing water. All control and interlock wiring to be furnished and installed under Division 23 Section, "Instrumentation & Controls of HVAC & Plumbing Systems"

2.21. FILTER MEDIA DURING CONSTRUCTION

- A. Filter media installed during construction: Minimum MERV 8.

PART 3. EXECUTION

3.1. DUCT INSTALLATION REQUIREMENTS

- A. Coordinate ductwork with other work and install ducts at proper elevations and locations to maintain indicated ceiling heights and clearances. Provide all elbows, transitions, offsets, connections, and other fittings necessary to fit the work into place or to connect to equipment or diffusers. Method of duct support connection to structure and slabs shall be approved by Structural Engineer, and Shop Drawings shall be submitted.
- B. Substantially support ductwork with structural shapes, flat bars, or formed strap hangers securely attached to the building structure by means of bolts, clamps, or inserts. Support vertical ducts by angles attached to the duct and resting on the floor or supported by brackets or hangers attached to the building structure. Strap hangers shall be 16-gauge minimum galvanized steel formed under the bottom edge of duct. Use square ¼ inch thick washers tight against the bend on upper strap attachments to horizontal surfaces. Place all supports external to the ductwork and out of the air stream. Provide additional supports at coils and other concentrated loads. Arrange supports so that duct weight is not transmitted to ceilings, fans or other equipment.
- C. Prevent direct contact between ductwork and building surfaces or other equipment. Where ducts pass through walls, partitions, floors, ceilings, or roofs, pack and seal the space around the duct with an approved fire-safe inert material. Provide flanged duct escutcheons at all exposed ducts that pass through walls, partitions, floors, and ceilings.
- D. Use galvanized (compatible) corrosion-resistant hangers, supports, brackets, and hardware.
- E. Furnish and install NFPA-approved duct connections where shown and at all connections to fans, air handling units, and similar rotating equipment. Use glass-reinforced neoprene fabric, roll-formed to sheet metal strips or flanges. Support adjacent ductwork to provide sufficient slack in the connection.
- F. See NFPA 90A, and latest publication of SMACNA. Prevent direct contact between ductwork and building surfaces or other equipment. The opening in the construction around the duct shall not exceed one-inch average clearance on all sides. Where ducts pass through walls, partitions, floors, ceilings, or roofs, pack and seal the space around the duct with an approved fire-safe inert material capable of preventing the passage of flame and hot gases sufficiently to ignite cotton waste when subjected to the same NFPA

251 Time-Temperature Conditions required for fire barrier penetration. All exposed duct penetrations shall be finished with a sheet metal field erected flange escutcheon to form a neat appearance.

- G. Coordinate duct installation with the requirements of Division 23 Section, "Vibration Controls for HVAC, Plumbing & Fire Protection Equipment".
- H. Install in accordance with manufacturer's instructions.
- I. Install and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- J. Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- K. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- L. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- M. Use crimp joints, with or without bead, for joining round duct sizes eight (8) inches and smaller with crimp in direction of air flow.
- N. Use double nuts and lock washers on threaded rod supports.
- O. Set plenum doors 6 to 12 inches (150 to 300 mm) above floor. Arrange door swings so that fan static pressure holds door in closed position.
- P. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork systems.

3.2. ACCESSORY INSTALLATION REQUIREMENTS

- A. Install accessories in accordance with manufacturer's instruction, NFPA 90A, and SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- B. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, duct detectors, air flow monitoring stations, duct-mounted equipment, duct coils and elsewhere as indicated. Review locations prior to fabrication.
- C. Provide duct test holes where required for testing and balancing purposes. Review locations with Test and Balance Engineer prior to installation.
- D. Provide fire dampers, combination fire and smoke dampers and smoke dampers at locations indicated, where ducts and outlets pass through fire-rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion-resistant springs, bearings, bushings and hinges.

- E. Install smoke dampers and combination fire and smoke dampers in accordance with NFPA 92A. Furnish and install a remote test station and connect to damper end switches.
- F. Demonstrate re-setting of fire dampers to Owner's representative.
- G. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment and supported by vibration isolators. Refer to Division 23 Section, "Vibration Control for HVAC and Plumbing Systems".
- H. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum duct widths from duct take-off.
- I. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
- J. Install diffusers, registers, and grilles to ductwork with airtight construction.
- K. Check location of all air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangements.
- L. Install duct thermometer support flanges in wall of duct. Attach to duct with screws. Locate duct mounted thermometers, minimum 10 feet downstream of mixing dampers, coils or other devices causing air turbulence.
- M. Install remote - reading duct dial thermometers in control panels with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length. Mount control panel 60 inches above finished floor and label each dial thermometer.
- N. Install duct accessories according to applicable details shown in SMACNA's HVAC Duct Construction Standards Metal and Flexible for metal ducts.
- O. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.
- P. Provide test holes at fan inlet and outlet and elsewhere as indicated.
- Q. Install fire, smoke, and combination fire and smoke dampers according to manufacturer's UL approved written instructions.
 - 1. Install fusible links in fire dampers. Label access doors according to equipment served.
- R. Adjust duct accessories for proper settings.
- S. Adjust fire and smoke dampers for proper action.

3.3. DUCT LINING INSTALLATION REQUIREMENTS

- A. All portions of duct designated to receive duct liner shall be completely covered with duct liner. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. The black pigmented or mat faced surface of the duct liner shall face the airstream.

- B. Duct liner shall be adhered to the sheet metal. with 90 percent coverage of adhesive complying with requirements of ASTM C916. All exposed leading edges and transverse joints shall be factory coated or coated with adhesive during fabrication. Install perforated galvanized inner liner where indicated
- C. Duct liner shall be additionally secured with mechanical fasteners, either weld-secured or impact-driven, which shall compress the duct liner sufficiently to hold it firmly in place. Adhesive bonded pins are not permitted due to long term adhesive aging characteristics. Spacing of mechanical fasteners with respect to duct liner interior width shall be in accordance with SMACNA HVAC DGS. Maximum spacing for mechanical fasteners shall be as follows:

Velocity = 0 to 2,500 feet per minute (0 to 12.8m/s):

From transverse end of liner	3: (75mm)
Across width of duct	12 inches (300 mm) O.C.
From corners of duct	4 inches (100mm)
Along length of duct	18 inches (450mm) O.C.

Velocity = 2,501 to 5,000 feet per minute (12.8 to 25.4 m/s):

From transverse end of liner	3 inches (75m)
Across width of duct	6 inches (150mm) O.C.
From corners of duct	4 inches (100mm)
Along length of duct	16 inches (400mm) O.C.

- D. When air velocities exceed 4,000 fpm (20.3m/s), galvanized sheet metal nosing shall be applied to all leading edges of duct liner.
- E. Acoustical Duct Liner shall be cut to assure overlapping and compressed longitudinal corner joints.
- F. Upon completion of installation of duct liner and before operation is to commence, visually inspect the system and verify that the duct liner insulation has been correctly installed.
- G. Open all system dampers and turn on fans to blow all scraps and other loose pieces of material out of the duct system. Allow for a means of removal of such material.
- H. Check the duct system to ensure that there are no air leaks through joints.

3.4. BOILER STACKS AND BREECHING INSTALLATION REQUIREMENTS

- A. Refer to “Condensing Boiler Intake” installation requirements for combustion air duct material.
- B. Install in accordance with manufacturer’s instructions.
- C. Install in accordance with NFPA 54 (ANSI Z223.1) and NFPA 31.
- D. Install breechings with minimum of joints. Align accurately at connections, with internal surfaces smooth.

- E. Support breechings from building structure, rigidly with suitable ties, braces, hangers, and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12 foot (4 m) spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for equivalent duct support configuration and size.
- F. Install concrete inserts for support of breechings, chimneys, and stacks in coordination with formwork.
- G. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.
- H. For double wall gas vents, maintain UL listed minimum clearances from combustibles Assemble pipe and accessories as required for complete installation.
- I. Install vent dampers, locating close to draft hood collar, and secure to breeching.
- J. Assemble and install stack sections in accordance with NFPA 82, Industry practices, and in compliance with UL listing. Join sections with acid-resistant joint cement to ASTM C105. Connect base section to foundation using anchor lugs.
- K. Level and plumb chimney and stacks
- L. Clean breechings, chimneys, and stacks during installation, removing dust and debris.
- M. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of breechings, breeching insulation, chimneys, or stacks.
- N. Provide maximum 2 feet of breeching to connect appliance to chimney.
- O. Do not install bull head tee at connections to equipment.
- P. Provide and install condensate neutralizer kit and piping as required by boiler manufacturer and breeching manufacturer.
- Q. Install duct thermostat in boiler flue breeching.

3.5. CONDENSING BOILER INTAKE DUCT INSTALLATION REQUIREMENTS

- A. Refer to “Stacks and Breeching” installation requirements for boiler flue material.
- B. Install in accordance with manufacturer’s instructions.
- C. Support intake pipes from building structure, rigidly with suitable ties, braces, hangers, and anchors to hold to shape and prevent buckling.
- D. Install concrete inserts for support of intake ducts in coordination with formwork.
- E. Level and plumb intake ducts.
- F. Clean intake ducts during installation, removing dust and debris.
- G. Provide and install condensate removal pipes and neutralizers per manufacturer’s

requirements.

- H. For condensing boilers provide and install flue pipe thermometers.

3.6. CLEANING

- A. Clean duct system and force air at high velocity through ducts to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.
- B. Clean duct systems with high power vacuum machines. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.
- C. Ductwork shall be cleaned in accordance with “Duct Cleanliness for New Construction (SMACNA 2000)”, and shall achieve a “Basic” cleanliness level.

3.7. LEAKAGE TESTS

- A. All low pressure sheet metal ductwork shall undergo leakage tests at 2 inch W.G. Tests shall be accomplished under this section and witnessed as specified under Division 23 Section, “Testing, Adjusting, and Balancing for HVAC and Plumbing”.
- B. Leakage from each duct system shall not exceed 5 percent for low pressure systems of the normal air handling capacity of the system. If the system ductwork is tested in sections, the leakage shall not exceed $\frac{1}{2}$ of 1 percent of the CFM to be handled by that section, and the total leakage of the system shall not exceed 1 percent of the total system CFM. Test pressure shall not exceed the pressure limits of the duct construction as defined in SMACNA High Pressure Duct Construction Standards. Repair all leaks which are audible, regardless of the leakage rate of the duct system as a whole, by remaking the entire defective joint or seam. Spot sealing of ducts in place will not be acceptable.
- C. All duct accessories, including but not limited to volume dampers, ATC sensors, duct detectors, duct coils shall be installed prior to duct leakage testing.
- D. Submit a complete report of the ductwork leakage tests to the Architect and include final approved copies in test and balance reports.

3.8. DUCTWORK IDENTIFICATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. All ductwork shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color Code and System Identification shall comply with ANSI Standards.
- C. Marking shall be plain block letters, stenciled on ductwork (above and below ceilings) and shall be located near each branch connection and at least every ten feet on straight runs of ductwork. Where ductwork is aligned adjacent to each other, markings shall be neatly lined up. All markings shall be located in such a manner as to be easily legible from the floor.

- D. Identify ductwork with plastic nameplates or stenciled painting. Identify with air handling unit identification and area served.
- E. Length of color field for ductwork shall be 32 inches. Lettering shall be minimum 3-1/2 inches high.

END OF SECTION

DIVISION 23 SECTION 238126
VRF SPLIT SYSTEMS WITH HEAT RECOVERY (AIR COOLED)
TABLE OF CONTENTS

PART 1. GENERAL.....	2
1.1. RELATED DOCUMENTS.....	2
1.2. SUMMARY	2
1.3. DEFINITIONS.....	2
1.4. SUBMITTALS	2
1.5. SYSTEM DESCRIPTION	4
1.6. QUALITY ASSURANCE	4
1.7. DELIVERY, STORAGE, AND HANDLING	5
1.8. WARRANTY	5
1.9. ALTERNATES	5
PART 2. PRODUCTS.....	6
2.1. MANUFACTURERS	6
2.2. OUTDOOR UNITS – AIR COOLED	6
2.3. BRANCH SELECTOR/HEAT RECOVERY BOX.....	7
2.4. INDOOR UNITS	8
2.5. CONTROL SYSTEM	9
2.6. WIRING.....	11
2.7. VRF/VRV SYSTEMS BACNET GATEWAY	11
2.8. FILTERS.....	12
PART 3. EXECUTION.....	12
3.1. EXAMINATION	12
3.2. INSTALLATION	12
3.3. CONNECTIONS	13
3.4. COMMISSIONING AND MANUFACTURER'S FIELD SERVICES	13
3.5. VRF INSTALLATION SUPPORT.....	15
3.6. DEMONSTRATION	16
3.7. TRAINING	16
END OF SECTION	17

SECTION 23 81 26

VARIABLE REFRIGERANT VOLUME SPLIT SYSTEMS WITH HEAT RECOVERY (AIR COOLED SYSTEMS)

PART 1. GENERAL

1.1. RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2. SUMMARY

- A. This Section includes Variable Refrigerant Volume Split Systems with Heat Recovery.
- B. Related Sections include the following. List below only products and equipment for this Project that the reader might expect to find in this Section but are specified elsewhere. Verify that the Section titles listed below are correct for this Project's Specifications.
 - 1. Division 23 Section, "HVAC Piping, Fittings and Valves" for refrigerant piping materials.
 - 2. Division 23 Section, "HVAC Insulation" for refrigerant pipe insulation requirements.
 - 3. Division 23 Section, "Vibration Controls for HVAC, Plumbing, & Fire Protection Equipment" for isolation materials.
 - 4. Division 23 Section, "Instrumentation & Controls of HVAC & Plumbing Systems" for temperature control devices, and control wiring and control devices connected to indoor, outdoor and refrigerant distribution devices.
 - 5. Division 26 Section, "Disconnect Switches & Circuit Breakers" and circuit breakers for field installed disconnect switches.

1.3. DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. EER: Cooling full load energy efficiency ratio.
- C. IEER: Cooling integrated (part load) energy efficiency ratio.
- D. High Temperature COP: Heating coefficient of performance at 42°F.
- E. Low Temperature COP: Heating coefficient of performance at 17°F.
- F. SCHE: Simultaneous cooling and heating efficiency.
- G. VRV: Variable Refrigerant Volume

1.4. SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated; dimensions; required clearances; shipping, installed, and operating weights; furnished specialties; accessories; and installation and startup instructions.
- B. Product data for Variable Refrigerant Volume units specified, including the following:
 - 1. Dimension and plans and elevation drawings including field piping, required clearances and locations of all field connections.
 - 2. Certified fan-sound power ratings.
 - 3. Certified coil-performance rating with system operating conditions indicated.
 - 4. Motor ratings and electrical characteristics plus motor and fan accessories.
 - 5. Filters with performance characteristics.
 - 6. Outdoor air cooled heat pump unit.
 - 7. Summary of all auxiliary utility requirements such as electricity, refrigerant piping, and condensate piping. Summary shall indicate quality and quantity of each required utility.
 - 8. Branch selector box data.
 - 9. Refnet data.
 - 10. ARHI 1230 certification including EER, IEER, high temperature COP, low temperature COP, and SCHE.
 - 11. Equipment selections de-rated to reflect scheduled data.
 - 12. VRV equipment certified installer's certificate.
 - 13. Wiring material product data and wiring layout for all systems: power, VRV control, control systems, interface to BMS and associated VRV equipment.
- C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail mounting, securing, and flashing of roof curb to roof structure for roof mounted units. Detail mounting and securing to concrete pads for grade mounted systems. Indicate coordinating requirements with roof membrane system or concrete pads and vibration isolation.
- D. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer installed and field installed wiring.
- E. Field Test Reports: Indicate results of manufacturer's startup and testing requirements. Submit copies of checklists.
- F. Maintenance Data: For equipment to include in the maintenance manuals specified in

Division 01.

- G. Warranties: Special warranties specified in this Section.
- H. Install factory certified documents indicating approval to install the VRV equipment.

1.5. SYSTEM DESCRIPTION

- A. Furnish and install where indicated, a variable capacity, heat recovery air conditioning system. System shall be a Variable Refrigerant Volume Series split system as manufactured by Daikin, LG, Mitsubishi, Trane, Samsung, Johnson Controls, or approved equal. The system shall consist of multiple indoor units capable of cooling or heating, branch selector boxes, refrigerant joints to separate refrigerant flow between units and headers (refnets), a three pipe or two pipe refrigeration distribution system using PID control, and an outdoor unit. The indoor units shall be connected to the outdoor units utilizing the specialized piping joints provided by the equipment manufacturer. The outdoor unit shall be direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with fixed speed and variable speed inverter driven compressors using R-410A refrigerant. The outdoor unit may connect to a connected indoor capacity up to 130% of the outdoor unit capacity. All zones are each capable of operating separately with individual temperature control. A dedicated hot gas pipe shall be provided to provide optimum heating operation performance.
- B. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with one branch cool/heat selector box. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a BMS interface. Provide all interlock wiring between system controllers and building automation system.
- C. Branch cool/heat selector boxes shall be located as shown on the drawing. The branch selector boxes shall have the capacity to control cooling and heating down stream of the box to each individual heat pump unit. The box shall consist of electronic expansion valves, refrigerant control piping and electronics to facilitate communications between the branch selector box and main processor and between the branch selector box and indoor units. The branch selector box shall control the operational mode of the subordinate indoor units. The use of electronic expansion valves ensures continuous heating during defrost, no heating impact during changeover and reduced sound levels.
- D. Manufacturer shall have five years prior experience making similar equipment as described in this specification.

1.6. QUALITY ASSURANCE

- A. All equipment and systems shall be tested and certified in accordance with AHRI 1230 (Performance Rates of Variable Refrigerant Flow (VRF) Multi-Split Air Conditioning and Heat Pump Equipment) and bear the AHRI certification seal.
- B. Fabricate and label refrigeration system to comply with ASHRAE 15, Safety Code for Mechanical Refrigeration.
- C. Listing and Labeling: Provide electrically operated components specified in this Section

that are listed and labeled.

1. The Terms Listed and Labeled: As defined in the National Electrical Code, Article 100.
 2. Listing and Labeling Agency Qualifications: A Nationally Recognized Testing Laboratory as defined in OSHA Regulation 1910.7.
- D. Comply with NFPA 70 for components and installation.
- E. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.
- F. The system shall be factory tested for safety and function.
- G. Coordination: Coordinate layout and installation of indoor units, outdoor units, refrigerant piping, branch selector boxes, refnets, and other appurtenances with piping and ductwork and with other installations.
- H. Contractor's certified VRV equipment installer must be on site during installation of VRV system, refrigeration piping, control wiring, system controls and interface to BMS, and associated VRV equipment.
- I. Obtain all necessary permits for low voltage and power wiring for VRV system.

1.7. DELIVERY, STORAGE, AND HANDLING

- A. Deliver outdoor and indoor units as factory assembled units with protective crating and covering.
- B. Coordinate delivery of units in sufficient time to allow movement into building or on to roof as indicated.

1.8. WARRANTY

- A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.
- B. Special Warranty: A written warranty, executed by the manufacturer and signed by the Contractor, agreeing to replace components that fail in materials or workmanship, within the specified warranty period, provided manufacturer's written instructions for installation, operation, and maintenance have been followed.
1. Warranty Period: Compressors and Compressor Motor Contactors: Manufacturers standard, but not less than 6 years after date of Substantial Completion.

1.9. ALTERNATES

- A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following: Retain above for nonproprietary or below for semi proprietary Specification. Refer to Division 1 Section "Materials and Equipment."
 - 1. Daikin, Samsung, Sanyo, LG, Johnson Controls, Mitsubishi, Trane, Samsung, Fujitsu, or approved equal.
- B. Basis of Design was a Daikin 3-pipe system. All scheduled capacities and efficiencies must be met. Cost of any electrical, piping, design, insulation, additional branch selector boxes, heat recovery boxes, refnets, or other changes associated with other approved manufacturers shall be included in the bid and shall be the responsibility of the Contractor. If manufacturer other than the Basis of Design is utilized and the same requires drains at branch selector boxes, Contractor must provide piping, insulation and if needed to condensate pumps at no additional cost to the Owner. This includes power requirements for condensate pumps. Quantity of compressor unit modules/compressors shall not be reduced.

2.2. OUTDOOR UNITS – AIR COOLED

- A. The outdoor unit is designed specifically for use with variable refrigerant volume system components. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, refrigerant regulator and all components for a complete functioning system.
- B. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
- C. The following safety devices shall be included on the outdoor unit; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
- D. Unit Cabinet: The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish. Units shall be provided with either factory furnished or field installed structural base for support.
- E. Fan: The unit shall have one or more propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter

type, and be of high external static pressure. A field setting switch to a maximum 0.32 in. WG pressure is available to accommodate field applied duct for indoor mounting of condensing units. The fan shall be a vertical discharge configuration and the motor shall have inherent protection and permanently lubricated bearings and be mounted.

- F. Condenser Coil: The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film and pipe plates shall be treated with powdered polyester resin for corrosion prevention.
- G. Compressor: Unit shall contain both fixed speed scroll and variable speed inverter scroll compressors. Inverter scroll compressors shall be variable speed (PAM inverter) controlled which shall be capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read and calculated. Each non-inverter compressor shall also be of the hermetically sealed scroll type. With each reading, the compressor capacity (INV frequency or STD ON/OFF) shall be controlled to eliminate deviation from target value. Compressors shall be spring mounted to avoid the transmission of vibration.
- H. Surge Protection: Provide unit with DIN Rail Plug-in Surge Protection for each compressor unit installed for all telecom and control circuits. Surge protection shall be factory or field installed per manufacturer's recommendations. Surge protectors shall be model DLA as manufactured by Citel or approved equal. Units shall be listed in accordance with UL497B.

2.3. BRANCH SELECTOR/HEAT RECOVERY BOX

- A. Branch selector (BS)/heat recovery boxes shall be located as shown on the drawing. The BS/heat recovery box shall be furnished with at least four (4) electronic expansion valves (EEV's), refrigerant control piping and electronics to facilitate communications between the BS/heat recovery box and main processor and between the BS/heat recovery box and indoor units. The BS box shall control the operational mode of the subordinate indoor units. The use of four (4) EEV's shall control the direction of refrigerant flow and ensure continuous heating during defrost, no heating impact during changeover and reduced sound levels. The branch selector/heat recovery boxes shall be designed specifically for use with heat recovery system components. These selector/heat recovery boxes shall be factory assembled, wired, and piped and shall be run tested at the factory. Unit Cabinet shall have a galvanized steel plate casing. Each cabinet shall house a liquid gas separator and contain a tube in tube heat exchanger. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene. Each circuit shall have at least one branch selector/heat recovery box to facilitate simultaneous heating and cooling in the system. Multiple indoor units may be connected to a branch selector/heat recovery box provided they are within the capacity range of the branch selector. The unit electrical power shall be as scheduled on the Contract Drawings. Each branch selector shall support up to four, six, eight, or ten heat pump units, each served by dedicated refrigerant suction and liquid piping. Each heat pump unit shall be able to individually operate in heating or cooling mode.

2.4. INDOOR UNITS

- A. Wall Mounted Indoor Unit - The unit shall be completely factory assembled and wired. The casing shall have a white finish. The evaporator fan shall be a high performance, forward curve line flow fan direct driven by a single motor. The fan shall be statically and dynamically balanced and run on permanently lubricated bearings. A manually adjustable change vane shall be provided. The vane shall have the ability to direct the air from horizontal to vertical. An adjustable guide vane shall be provided to manually change the air direction from left to right. The evaporator coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phosphor copper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan with drain shall be provided under the coil. Manufacturer shall furnish condensate lift pumps for field installation within the indoor unit. Condensate pumps shall be complete with float switch sensor, alarm, reed switch, relay, contact, adapters, and detection block etc., for a completely operational system. Contractor shall mount, pipe, and wire condensate pump per split system heat pump manufacturer's recommendations. The unit electrical power requirements shall be as scheduled on the contract drawings. Furnish with condensate overflow float switch that will shut down unit should a high condensate level condition be sensed.
- B. Ceiling Cassette Indoor Unit - The unit shall be completely factory assembled and wired. The casing shall be galvanized sheet with grey heat insulation. This unit shall fit in the ceiling and have the capability of attaching a branch supply duct as well as a fresh air duct. The evaporator fan shall be an assembly with a high performance, fan direct driven by a single motor. The fans shall be statically and dynamically balanced and run on permanently lubricated bearings. The indoor unit shall have an adjustable air outlet system offering 4-way air flow, 3-way air flow, or 2-way air flow. The auto air swing vanes shall automatically swing up and down for uniform air distribution. Return air shall be filtered by a long-life filter to provide approximately, 2500 hours of use in a normal office environment before cleaning. The indoor unit shall be covered with a flat panel which protrudes only 1 inch below the ceiling to provide a neat and clean installation. The coils shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tubes joints shall be brazed with phosphor copper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan shall extend under the coil and piping. An integral drain pan pump capable of lifting condensate 22 inches shall be provided. An integral booster heater shall not be provided to supplement the unit during the heating mode. The unit electrical power requirements shall be as scheduled on the contract drawings. Furnish with condensate overflow float switch that will shut down unit should a high condensate level condition be sensed.
- C. Ceiling Concealed Ducted Unit - The indoor unit shall be a built-in ceiling concealed fan coil unit, low static pressure (LSP), for installation into the ceiling cavity. The unit shall be constructed of a galvanized steel casing and shall be manufactured for a horizontal discharge air with horizontal return air or bottom return air configuration (as scheduled or shown on the drawings). The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have a booster cable for adjustable static pressure capability. The indoor units shall

be equipped with a condensate pan and condensate pump. The condensate pump shall provide up to 18" of lift from drain connection. The indoor units shall be equipped with a return air thermistor. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation. The fan shall be direct-drive Sirocco type fan, statically and dynamically balanced impeller with high, medium and low fan speeds and the fan motor shall be thermally protected. The return air shall be filtered by means of a washable long-life filter with mildew proof resin. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance. The coil shall be a 3 row cross fin copper evaporator coil with 14 FPI design completely factory tested. A thermistor shall be located on the liquid and gas line. Install sheet metal auxiliary drain pans with overflow switches for all ducted units. Furnish with condensate overflow float switch that will shut down unit should a high condensate level condition be sensed.

2.5. CONTROL SYSTEM

- A. The control system shall consist of multiple microprocessors interconnected by a single non-polar two wire multiplex transmission system. Wiring shall be daisy chained from unit to unit direct. NO SPLICES. One microprocessor shall be factory wired and located within each indoor unit. It shall have the capability of sensing return air temperature and indoor coil temperature; receive and process commands from the remote controller. The microprocessor within the wall mounted remote controller shall provide automatic cooling and heating system changeover; display set point and room temperature; a 24 hour on/off timer so that automatic operation can be set on the timer at one hour intervals from one to twenty-four hours; have self-diagnostic function display; check mode for memory of most recent problem; and provide on-off and system/mode function switching. The heating system shall be controlled so that only warm air is discharged whenever the fan speed exceeds the very low (VLO) speed. Normal operation of the remote controller provides individual system control in which one remote controller and one indoor unit are installed in the same room. The control voltage between the indoor units and the outdoor unit shall be 16 volts D.C. 16 VDC shall be generated from the outdoor unit microprocessor board. The system shall be capable of automatic restart when power is restored after power interruption. System shall include twenty function self-diagnostics including total hours of compressor run time. Compressor capacity shall be modulated automatically to maintain a constant suction pressure, while varying the refrigerant volume for the needs of the cooling or heating loads. Indoor units shall use PID control to control superheat.
- B. To prevent vandalism, wall mounted remote controllers shall be located in a concealed location for toilet room units. Unit control shall be based on return air temperature sensor.
- C. System Controller: Control system shall include a central controller for user interface with system. Controller shall include a Liquid Crystal Display (LCD) touch screen capable of controlling up to 16 outdoor units and 64 indoor unit groups (maximum 128 indoor units).
- D. System Controller shall be able to control the following functions:
 - 1. On/Off selection for each indoor unit group or zone that is defined with several indoor unit groups.

2. Setpoint adjustment for each indoor unit group or zone.
 3. Fan speed adjustment for each indoor unit group or zone.
 4. Heat/cool/fan mode selection for each indoor unit group or zone.
 5. Automatic changeover and antifreeze/overheat protection.
 6. Forced shutdown terminals.
 7. Priority settings for restriction of local access for start/stop, heat/cool mode and setpoint adjustment (at local remote controllers).
 8. Setpoint limitation in both heating and cooling mode.
 9. Weekly schedule with start-up and shut off times, temperature settings, and operation modes; 16 operations/each day can be set in one schedule, and 8 different schedules are available for special working days, holidays, or period of non-use.
 10. Actual time display and setting.
 11. Reset ability for malfunction codes and filter maintenance warning.
 12. Maximum 13 months back up power supply to maintain the memory.
 13. Non systems units (e.g. energy recovery ventilator) can be started/stopped and general alarm/status reported using Digital Input or Digital Input/Output units, including interlock program.
 14. Controller must be BACnet compatible.
- E. Controller shall provide control transformer for 24 VAC supply voltage for controllers as required.
- F. Provide interface devices as required to interface to Building Automation System. ATC Interface shall allow monitoring of all points indicated on the point list.
- G. Furnish the controls with the necessary interfaces to communicate via BACnet/IP or LonWorks to a building automation system. Exact protocol to be determined by the ATC subcontractor and VRV installing contractor.
- H. All inputs and outputs on the manufacturer's controller shall be viewable via the interface.
- I. All set points and schedules shall be editable via the interface by the building automation system.
- J. In addition to standard inputs/outputs provide additional input/outputs as required to accomplish sequence of operation and items listed on point list.
- K. The manufacturer shall be responsible for assisting and participating in the integration of

the equipment into the building automation system and shall provide programming support, testing, verification, and on site personnel as required.

2.6. WIRING

- A. All wiring devices and wire/cable shall be approved for the proposed purpose.
 - 1. Communication cable shall be indicated for use in the data sheet
 - a. Bacnet
 - b. Lon
 - c. RS-232
 - d. RS-485 for VRV Loop wiring
 - 2. All wire/cable shall be installed per VRV and wire/cable manufacturers' data sheets.
 - 3. All wiring devices and wire/cable shall be labeled by UL or approved listing agency.
- B. All installation contractors must have one person on site with five years experience in the trade during the complete installation process.
- C. All wiring shall be installed per National Electric Code, BICSI and all other codes.
- D. All wiring shall be installed in a neat, best and most workmanlike manner using the proper hangers and the protection of wiring in the installed method used.
- E. Installing contractor must supply an electrical permit for record purposes before work begins.
- F. Equipment supplier equipment shall not be installed as a single point of failure by the control contractor.
- G. Equipment manufacturer shall supply control contractor with a pre-wired and tested control NEMA 1 enclosure with gateway, power supply and terminal strips. A complete set of wiring diagrams for the interface must be submitted and included in the O&M manuals.
- H. Control panel power shall have a separate 120 volt single phase circuit with no other load on the circuit.

2.7. VRF/VRV SYSTEMS BACNET GATEWAY

- A. The VRF/VRV Systems BACnet™ Gateway shall be capable of monitoring up to 256 indoor units and 64 outdoor units through its embedded web browser. The BACnet Gateway shall be capable of controlling 92 indoor units and 8 outdoor units through its embedded web browser with third-party Building Automation Systems interface. The BACnet Gateway provides multiple energy management schemes and integrates with third-party Building Automation Systems.
- B. Provide multiple Gateway BACnet controllers as required, based on quantity of

equipment on project.

2.8. FILTERS

- A. In addition to the washable filters provided with each indoor unit, provide two (2) sets of spare additional washable filters for every indoor unit on the project. Provide correspondence documenting filters have been turned over to Owner at Substantial Completion.

PART 3. EXECUTION

3.1. EXAMINATION

- A. Examine space for compliance with requirements for conditions affecting installation and performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2. INSTALLATION

- A. Mount indoor and outdoor units as detailed on contract drawings and according to manufacturer's written instructions.
- B. Install all interlock and control wiring between indoor units, outdoor units thermostats, and condensate pumps.
- C. Supply initial charge of refrigerant and oil as required.
- D. Install indoor ceiling cassettes and ducted units on vibration isolators.
- E. Install outdoor units on concrete pads or on roof curbs as indicated on drawings.
- F. Comb out fins on condensing unit where deformed or bent. Replace or repair broken fins.
- G. Install condensate lift pumps, float switches, alarm, unit shut down wiring and detection block units per manufacturer's recommendations.
- H. For wall mounted units field wire power wiring, alarm circuits, control cable, safety circuit connection, alarm, and condensate pump. Condensate pump shall be powered from indoor unit power wiring. Coordinate condensate pump electrical characteristics with indoor unit electrical characteristics.
- I. Install system controller and interlock all indoor and outdoor units.
- J. Install lockable caps on all outdoor unit refrigerant service valves to prevent tampering.
- K. All final pipe lengths shall be submitted to VRV manufacturer to verify compliance with manufacturer's requirements.
- L. Install all refrigerant piping per manufacturer's requirements without deviation.
- M. Label and identify all indoor units, outdoor units, piping, and branch selector boxes.

- N. Install refnets and Y-fittings with manufacturers' required unobstructed distances upstream and downstream of the same.
- O. Submit pressure test reports and vacuum test reports as informational submittals.
- P. Install all branch selector boxes with manufacturer's required clearances. Also branch selector boxes shall be installed level per manufacturer's requirements.
- Q. Install, test, and inspect refrigerant piping systems per manufacturer's instructions.

3.3. CONNECTIONS

- A. Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:
 - 1. High/low pressure gas line, liquid and suction lines must be individually insulated between the outdoor and indoor units.
 - 2. Refrigerant Piping: conform to applicable requirements of Division 23 Section, HVAC Piping, Fittings, and Valves.
 - 3. Install refrigerant piping, refnets, Branch selector boxes, insulation, and control wiring as required by the manufacturer.
 - 4. Install isolation valves on all three pipes between outdoor unit and branch selector boxes.
 - 5. Install isolation valves on both pipes at every indoor unit.
- B. Electrical: Conform to applicable requirements in Division 26 Sections.
- C. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4. COMMISSIONING AND MANUFACTURER'S FIELD SERVICES

- A. Verify that installation is as indicated and specified. Provide factory authorized start-up and training.
- B. Complete manufacturer's installation and startup checks and perform the following:
 - 1. Inspect for visible damage to unit casing.
 - 2. Inspect for visible damage to compressor, air cooled condenser coil, and fans.
 - 3. Verify that clearances have been provided for servicing.
 - 4. Check that labels are clearly visible.

5. Clean condenser and inspect for construction debris.
6. Verify wiring is installed per VRF installation manual requirements including but not limited to the following:
 - a. Grounds
 - b. Shielding
 - c. Prior to applying power perform and document end to end continuity test for each wire in the communication cable.
7. Verify piping is installed and tested.
8. Verify that controls are connected and operable.
9. Verify that filters are installed.
10. Adjust vibration isolators.
11. Verify all piping and branch selector boxes are insulated.
- C. Start unit according to manufacturer's written instructions.
 1. Complete startup sheets and attach copy with Contractor's startup report.
 2. Start-up units in close coordination with testing/balancing.
- D. Check and record performance of interlocks and protection devices; verify sequences.
- E. Operate unit for an initial period as recommended or required by manufacturer.
- F. Calibrate thermostats and humidity sensors.
- G. Check internal isolators.
- H. Start refrigeration and measure and record the following:
 1. Coil leaving air, dry and wet bulb temperatures.
 2. Coil entering air, dry and wet bulb temperatures.
 3. Refrigerant suction/discharge pressures.
 4. Indoor and outdoor unit amperage, voltage, and watts.
 5. Fan Rotation and RPM.
 6. Condensate pump operation.
 7. Condensate overflow safety switch operation.
 8. System controller operation.

3.5. VRF INSTALLATION SUPPORT

- A. The authorized manufacturer's representative shall include installation support for the project as specified in this section by means of a dedicated technical VRF support specialist.
- B. This project support shall be completed by an employee whose sole responsibility is to provide direct technical support for the VRF system. Sales staff or other roles are not permitted to provide these duties.
- C. The VRF support specialist must be available for a kick off meeting prior to work being started. This meeting should include the installing contractor, engineer, controls contractor, owner (or owner's representative) and general contractor.
- D. This meeting shall cover the following items:
 - 1. Review installation best practices for the VRF manufacturer.
 - 2. Review mechanical drawings and VRF system layout.
 - 3. Provide contact information for support during the project.
 - 4. Review integration requirements and mapping of points with ATC sub-contractor.
- E. Project support by the manufacturer's representative during the project shall include the following:
 - 1. Provide periodic onsite technical support for the installation contractor during the project.
 - 2. Review as-built information provided by the Mechanical Contractor.
 - 3. Provide documented reports and recommendations to the installing contractor.
- F. The manufacturer's representative shall monitor progress of the installing contractor and support set up of the VRF system prior to system start-up.
- G. The mechanical contractor shall provide all functions of the installation of the VRF system but not limited to the following:
 - 1. Piping per manufacturer's recommendations within the design software guidelines furnished by the manufacturer's representative.
 - 2. Wiring per the manufacturer's recommendations.
 - 3. Brazing with nitrogen per manufacturer's recommendations.
 - 4. Pressure testing to 550 psi pressure test for 24 hours. This must be documented and verified by the VRF support specialist from the manufacturer's representative.

5. Evacuation of the system to 500 microns. This must be documented and verified by the VRF support specialist from the manufacturer's representative.
 6. Providing as-built piping information throughout the project must be documented and verified by the VRF support specialist from the manufacturer's representative. This is necessary to provide accurate refrigerant charge to be added by the installing contractor.
 7. Proper set up of the VRF system addressing.
- H. Start-up assistance for the installing contractor shall be provided by the VRF manufacturer's representative with the following guidelines:
1. The manufacturer's representative shall assist with starting the system and verifying that all VRF equipment is communicating properly and operating within the pressure and temperature guidelines of the VRF manufacturer.
 2. The manufacturer's representative must compile 1 hour of operational runtime data per system during this start-up.
 3. The manufacturer's representative will not be responsible for troubleshooting wiring, installation of any components, evacuation or pressure testing of the systems.

3.6. DEMONSTRATION

- A. Engage a factory authorized service representative to train Owner's maintenance personnel as specified below:
1. Review data in the maintenance manuals. Refer to Division 01 Section, Contract Closeout.
 2. Review data in the maintenance manuals. Refer to Division 01 Section, Operation and Maintenance Data.
 3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

3.7. TRAINING

- A. The Variable Refrigerant Volume Split System manufacturer shall include in his bid, provisions for additional training at the company's regular school or training center. The VRV manufacturer shall include in his bid all costs associated with sending two (2) individuals to the VRV manufacturer's school for a period of not less than one (1) week. This training is in addition to the aforementioned training required under the General Provisions.
- B. The training time period shall be coordinated with the school districts facility Engineer. The schedule training period shall be arranged at the owner's convenience.
- C. Cost shall include all training material, instruction books, and two copies of video tape

with sound DVD of training session.

- D. Upon completion of the work, the Contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on the operation of the VRV split system for a period of not less than four (4) four (4) hour days. All training shall be by the VRV split system manufacturer and shall utilize specified manuals and as-built documentation.
- E. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.
 - 2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. Include a minimum of 40 hours' dedicated instructor time on-site.
 - 3. Review data in maintenance manuals. Refer to Division 01 Section, Contract Closeout.
 - 4. Review data in maintenance manuals. Refer to Division 01 Section, Operation and Maintenance Data.
 - 5. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION